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CONCEPT DEVELOPMENT OF SATURN SERVICE STRUCTURE NO. II, Part One

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Prepared by:

J. H. Deese

1 April 1963

Presented to the Am. Inst. for Steel Construction, Tulsa, Okla., Apr. 25, 1963

NASA LAUNCH OPERATIONS CENTER
CAPE CANAVERAL, FLORIDA
Fla.

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Part One

CONCEPT DEVELOPMENT

OF

SATURN SERVICE STRUCTURE NO. II

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Part One of speech to be presented to the American Institute for Steel Construction in Tulsa, Oklahoma, on April 25, 1963.

Part One

ABSTRACT

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The elementary parameters for development of the Launch Complex and Service Structure concepts were defined by the relationships of climate and geographical location to the optical and EM tracking stations of the ground plant and by the Space Vehicle configuration. Details for design derive from functional "check-out" and count down sequences, and from lift-off characteristics of the vehicle. Particular influencing factors are stage and component dimensions, weights, requisite handling techniques and assembly methods, and launch team organization. Multi-stage vehicles like SATURN-I and C-2 require service structures with adjustable, multi-level personnel-access platforms and umbilical towers. Rail-traveling, mobile service structures and fixed umbilical towers are most feasible for these vehicles. Eleven structural concepts for service structures are presented in the figures included in this paper, which include the vertical face, trapezoidal, open structural frame (120 ft. x 120 ft. base by 300 ft. high) selected for duty at Launch Complex 37, Cape Canaveral.

Author

PART ONE

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PART ONE

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Part One of Speech to be Presented to the American Institute for Steel Construction in Tulsa, Oklahoma April 25 - 26, 1963

SPEECH

CONCEPT DEVELOPMENT OF SATURN SERVICE STRUCTURE NO. II LAUNCH COMPLEX 37

by

James H. Deese

I. INTRODUCTION

The history of the Von Braun team is one of progress both in space vehicles and in service structures. These towers at Canaveral are particular parts of each missile and space program.

The schedule and experiences in acquiring the Canaveral launching plant for the V-2 Bumper, Redstone, and Jupiter Missiles are prelude to our present effort. Figure 1 presents the time and cost plots of this progress. I believe this history to be significant; future projection becomes astounding. In time scale, we are now well down the road in the National Effort of the Saturn I Program.

Symbolic of the Redstone, Jupiter, and Juno Programs were the "A" frame structures, each with its extension hammer-head. The "Green Room", from which astronaut Alan Shepard stepped aboard the Mercury-Redstone for the first American Manned Rocket Flight, was supported by one of these structures. In fact, that structure was the grandfather of all the structures at Canaveral; it was delivered and placed in operation in June, 1953. Its weight was 390 tons; erection time four days; height 141 feet, (Fig. 2).

In the Saturn Program, a new order of magnitude came into both space vehicle rocketry and the ground support plant at which the vehicle would be launched. The service structure (Fig. 3) now serving the Program at Launch Complex 34 has a height of 311 feet to the top, and a total weight of 2800 tons. Initial concepts were developed in 1959; the Structure was placed in service during mid spring of 1961. This structure was designed to serve only one launch pedestal; although not an optimum, it has done its job well.

II. GEOGRAPHICAL LIMITATIONS

Our first studies on the Atlantic Range in 1951 showed it undesirable to over-fly either continental United States, U.S. territories, or foreign territories. Because of this, firing azimuths were limited between North 42 degrees East and North 115 degrees East (Fig. 4).

The Redstone, Jupiter, and Atlas vehicles are all single stage. The philosophy in firing these vehicles was that the main boosters would disintegrate and disperse on re-entry into the atmosphere. The Saturn vehicles are multi-stage. The first stage of the Saturn never leaves the atmosphere and therefore must have an impact zone. This zone is provided by that sector of the Atlantic Ocean contained between these two azimuths. For both lunar and planetary missions, it is desirable to retain as much of the earth's surface rotational momentum as possible; easterly launchings preserve this vector.

Prior to launching, the space vehicle is serviced and monitored through umbilical connections to each stage. Relative to the centerline of a vertical space vehicle ready for launching, the umbilical connections are usually in the same vertical plane. The Umbilical

Tower is the pillar to which the umbilical swing arms are connected. On firing of the space vehicle, these arms disconnect and swing clear of the vehicle's flight path.

In flight, the space vehicle is monitored from telemetry, radar, radio-link, and optical ground stations. Each of these stations must be "locked" onto the space vehicle before "lift off". For this reason, the Umbilical Tower and the ground instrument stations must be located so there will be no interference with the requisite lines of sight. The Service Structure, in its parking position, also must not interfere with the lines of sight from the space vehicle to its ground monitoring stations.

III. SERVICE STRUCTURES AND UMBILICAL TOWERS

Service Structures and Umbilical Towers are used for erection of a space vehicle and for personnel access and ground services to the vehicle during pre-firing preparations and functional "checkouts" of the vehicle, its components, and "on board" trajectory operating systems. These preparations and checkouts are performed during the pad stay time.

A. Utilization functions of the structure must provide:

1. Servicing and setting of the launch pedestal and its components.
2. Erection and dismantling of the multistage space vehicles, payloads, stages, and components from transporter equipment to launch position.
3. Personnel accessability to vehicle mating stations for erection, and to vehicle access openings for removal, installation, test, calibration, and servicing of on board equipment. This includes guidance, control, propulsion, mechanical, electronic, tracking and measuring equipments.
4. Storage and operating areas, at required access positions, for servicing and testing tools and equipment.

5. Pipe and flex tube ways for propellant and gas supply lines to all stages. Communication and test cable ways to all stages are also provided.

6. Adequate weather and lightning protection for the space vehicle and its components.

7. Pre-launch ready access and exitways for space crews, their ground service team, and for manned payloads.

8. In special instances, "Hold Down" of the vehicle for static firings and full thrust attainment at launch, together with necessary flame control devices.

The service structure, umbilical mast, and launch pedestal comprise the basic handling system to position the space vehicle and its components for the launch operation.

The Elementary Concept is derived from these functions; but this concept is heavily influenced by the performance characteristics of the missile at "lift off", during early flight, and by the ground orientation of the launching site within the launching plant. Allowable ground sectors

from the launch point, for the service structure retraction and parking and for the Umbilical Tower location, are determined by overlaying the required space vehicle departure azimuths and lines of sight on the Master Plan Map. Structure positions too close to optical and electro-magnetic lines of sight will invalidate prelaunch calibration data.

B. MISSILE AND SPACE VEHICLE DATA required for development of these equipments includes:

1. Departure azimuth for each mission at "lift off".

2. Trajectory and vehicle program of each mission, with reliability factors and maximum wind drift cone envelope.

3. Configuration and weight of each space vehicle component stage, and lift off weight of each type propellant.

4. Method of mating each stage, payload, instrumentation compartment and auxiliary rocket motors. Required points of access to each of these including their component locations and required

points for servicing and propellant charging.

5. Mode of transport, allowable suspension points and rings, structural strength data, and handling weights of each stage and its major components, instrumentation compartment and payload.

6. Allowable overpressure and impulse loading, wind resistance, and deflection characteristics of assembled vehicle with payloads.

7. Orientation, vertical station, size, quantity, and other information of required umbilical cable and piping connections.

8. Count down chart with functional statement of services, tests, and operation time sequencing of "on board" and related ground systems, from initial delivery of the first vehicle component to the launch pad until "lift off" and separation of umbilical connections and trailing wires.

C. PERSONNEL AND EQUIPMENT PROGRAMMING required by each function at each station, as listed from the Count Down Chart, should be obtained from the firing team organization. Accessibility of personnel must be guaranteed to each component requiring service, inspection, or removal.

Equipment sizes and weights must be listed. Communications nets required for checkout and "in line" reporting to the firing director from the structure, umbilical mast, and pedestal must be similarly obtained.

D. LIFTING AND ERECTION METHODS are as varied as the number of designs under current practices. Variations in primary concepts are influenced by structural limitations of the missile. Selection of proper handling capability is fundamental to utilitarian aspects of the service structure. With vehicles (such as Saturn Stages) sufficiently strong to support their own weight, two-hook lifting, at one forward and one aft point, has been highly successful. For vehicle stages and payloads transportable in an upright position, single-hook lifting with yoke and sling is utilized.

E. UMBILICAL MASTS AND TOWERS have also been designed and used under varying concepts. With increasing height of the space vehicle, the problem becomes more complex. Because their cost is fractional compared to a Service Structure, umbilical masts are usually considered expendable.

At first for missiles such as the REDSTONE, wooden poles and fixed steel pipe masts were used to suspend the ground end of the catenary cable which connects to the vehicle umbilical plug. Introduced as a refinement to this concept were umbilical masts of 5 and 6 inch diameter metal tubing. These were used on JUPITER and REDSTONE; they extend from the hinged point at the pedestal to the umbilical connector block at the instrument compartment.

For very large vehicles of SATURN class, free standing umbilical towers are used. On launching, the arms retract in telescoping action from the missile and are swung clear of the drift cone by pneumatically operated hydraulic pistons.

F. SERVICE PLATFORMS of the Structure are provided at each required access level of the space vehicle. Experience has proven that powered vertical travel and adjustment is frequently necessary. Platform repositioning may be required for access, to clear missile "on board" antennas, for connecting and servicing propellant venting and piping systems, obtaining line of sight in laying the guidance tables, mating vehicle stages and payloads, and

for numerous other purposes. Where work process requires weather protection for personnel and equipment, provision is made for enclosing that platform. Platforms for propellant loading should be open ventilated where practicable to provide safety precautions in compliance with code requirements for ventilating and electrical apparatus. Positive ventilation, providing concentration of not more than 50% of toxic or explosive limits, is necessary. Although "on board" apparatus and test equipment for space vehicles are not normally "explosion proof" under prelaunch servicing conditions, design of the "service structure" must preclude its contribution to any on-pad catastrophe.

IV. OPERATING ENVIRONMENT AND CONDITIONS

The climatological data for operating exposure at Canaveral is best expressed by Table III. The climate is that of a sub-tropical temperature zone at seaside location. Salt-laden fog and ocean spray mists are frequent; sun exposure is severe. Any unhoused object is subjected to daily dew deposits occasioned by the high diurnal variation; with high winds normal to the Trade Wind Area, blowing sand is frequently experienced (up to 250 to 300 ft. high under adverse conditions).

Since Canaveral is in the hurricane zone, particular operating considerations must be made relative to the wind conditions.

A structure, either in parked position or at the pad without vehicle, must be secured at 40 knots by auxiliary anchorage, and at 55 knots with full anchorage in service. A structure should be able to move in winds up to 40 knots at speed of $1\frac{1}{2}$ to 40 feet per minute. When fully anchored, a structure should withstand full hurricane duty - 125 knot winds.

With a space vehicle in the structure, equipment should be lightly secured for winds above 40 knots.

Above 55 knots, the vehicle should be tied to the structure; the tying equipment must not induce detrimental forces in either the service structure or the vehicle. In the event of a hurricane warning, all operations should cease and the vehicle should be secured when the wind reaches 55 knots.

In case of thunderstorms or gust warnings, the structure should be able to move from the parked position back to the vehicle on the launcher in from 30 to 45 minutes.

The SATURN C-2 vehicle configuration, when not tied down under 39-40 knot wind condition, would have had an estimated allowable deflection of 18 inches at the top. Of this figure 15% would be due to the launcher, 8% due to weight displacement of CG's and the remainder due to wind. The S-I booster has a permissible deflection of 8 to 9 inches at top and is capable of standing alone during a hurricane.

When an early hurricane warning is received, the upper stages of a SATURN-I vehicle at LC 34 must be taken down. This operation requires at least a half day per upper stage.

The upper stages would have to be dismantled under anticipated squall winds of, say, 60 knots, if a "lightweight" type service structure were used. Because such wind conditions occur with less than one hour warning, there is insufficient time to take down the upper stages.

V. HISTORY AND BACKGROUND

Early in 1960, Dr. Kurt Debus, Director of NASA Launch Operations Center at Cape Canaveral, appointed a committee to critically examine the LC 34 Service Structure and develop guidelines for a new design approach in future Service Structures. Mr. Pierce of Maurice Connell and Associates and myself were both members of this committee. This committee found that, due to changes in transport concepts at the launch pad, the inverted U frame of the LC 34 concept was functionally not the most desirable from considerations of cost, weight, base size, stiffness and efficiency of utilization.

The follow-up study by this original committee with added membership (including the firm of Metcalf and Eddy), recommended a new approach, based on a Progressive Design considering the Service Structure as a service tool of diversified functions. New concepts were to be optimized with limitations only as imposed by the Saturn configuration. From this guideline, the resulting study included concepts of handling, fueling, servicing, and the relationship of the Space Vehicle to all other associated facilities.

The Service Structure was to be based on three configurations developed from the Saturn C-2 series vehicles. Table I shows the building block makeup for configurations A, B, and C. Notably, the payloads were not defined. It was understood that some would be manned, some would be orbital vehicles, and some would be scientific space probes; even logistic freight payloads were considered.

Table II shows significant dimensions of these basic building blocks or STAGES. For flexibility, the crane hook height was selected at 300 ft. with capability of extension to 350 ft. The launch table height was taken as 35 ft. with table top dimensions of 50 ft. by 50 ft.

At first, fixed service structure appeared to effect impressive economies and excellent utilization. Such assumption erroneously excluded requirements for umbilical tower, traction equipment, rail beams and their foundations, parking foundation and securing devices. The evaluation had to consider time and cost impact in event of an abort explosion and the economic effect of long cantilevered platforms (permitting the main structural frame to be outside the drift cone of the Space Vehicle).

The mobile service structure was found most desirable; favorable consideration of the fixed service structure was deferred pending development of Saturn launching reliability.

VI. STRUCTURE CONCEPTS

A total of 21 structure concepts were reviewed and evaluated by the committee. Of these, 9 mobile concepts were generated within NASA organizations and 8 mobile concepts were generated by engineering consultant members. A total of 4 fixed concepts were reviewed; 2 fixed concepts from NASA sources and 2 from Architect Engineer sources.

Some of the more interesting of these will be shown.

A.	Inverted "U" Structure with Cross Bracing	Fig. 6
B.	Extensible Structure	Fig. 7
C.	Open "C" Structure	Fig. 8
D.	Unique Service Structures:	
	1. With Booster Flush with Ground	Fig. 9
	2. With Top at Ground Level	Fig. 10
E.	Movable Launcher	Fig. 11
F.	Vertical Face, Trapezoidal Frame Structure	Fig. 12 Fig. 13A, B and C
G.	Stationary Service Structure	Fig. 14
H.	Open-Cylindrical -- Column Fixed Structure	Fig. 15 and 16

I.	Revised Stationary Service Structure	Fig. 17
J.	Smokestack Concept	Fig. 18A and B

In these structure concepts, the trapezoidal frame seems to predominate.

VII. IDEAL SERVICE STRUCTURE GUIDELINES

The committee concluded that a mobile-type service structure should be used. No individual design was selected. Rather, it was decided to choose those combined features which would produce the most ideal service structure satisfying SATURN-C2 operational requirements. These are listed below:

A. Configuration:

The service structure height was selected to be approximately 360 feet to accommodate a 300 ft. vehicle; it was to be vertically extensible by 50 ft. Base dimensions were not to exceed 120 feet square. Weight was estimated between 2000 to 2400 tons. Deflection was to be less than 12 inches at the 300 foot level in 125 mph winds.

The structure was to be open front and rectangular in plan; both front and side elevations were to be trapezoidal and the front face was to be vertical. Of the considered concepts the trapezoidal frame predominated.

...uction was to be either of standard rolled steel structural or tubular shapes of

welded fabrication with high strength bolted field connections. Panel spacing was to be optimized for economical utilization of structural material.

B. Platforms:

Fixed platforms were to be provided at each panel location.

Six to ten moveable access platforms were expected for servicing all vehicle configurations of the C-2 series.

Each platform was to consist of three sections, the rear section being secured in a recess in the front face of the service structure; the other two swinging sections being hinged.

Each central opening of the service platform was to be adjustable as a camera iris to fit expected vehicle diameters and provide clearance for maximum deflections. Adjustment was to be by interchangeable metal inserts. The clearance for deflection was to be closed by sponge rubber or inflatable rubber tubes.

Electrical and other utilities connections were to be flexible and extended from risers.

on the main frame to receptacles and cabinets at the rear of the service platforms without dragging cables between the structure and platforms.

C. Enclosure for the Vehicle:

The committee recommended protecting the vehicle with a sectional hinged, silo-type, frangible enclosure. This would protect against flying debris during hurricanes or tornadoes and shield against wind loading. Such enclosure would provide a still air environment; deflection would be minimized and alignment measurements facilited. Requirement would be eliminated during high winds for either disassembling the vehicle or tying it to the service structure.

An increase in cost and weight was anticipated as well as complication effects on the structure. Stack effects might create personnel hazards in case of propellant fires. If such enclosure were not used, the vehicle would be tied to the structure to withstand wind loading.

The erected booster would not require ties. Should upper stages not to be removed during the 24-hour hurricane alert, ties would have to be made between strong points built into the vehicle near each mating point of the vehicle stages and the service platforms or service structure; this would force the service structure deflections into the vehicle.

D. Hoisting and Handling:

A stiffleg derrick with 60 ton main hook and 10 ton auxiliary hook was to be mounted atop the structure. With a stiffleg derrick, handling and assembly operations of hardware would require more careful control than with a bridge crane. The derrick was preferred because of increased flexibility. In conjunction with the main derrick, a 40 ton mobile crane with 60 foot boom was to be used to hoist and position the tail of the booster and stages from their transporters prior to erection. This crane could also have been utilized for handling the flame deflector.

E. Elevators:

Two passenger elevators were to be provided; each to be 4 feet by 6 feet, of 1500 lbs capacity; and one combination freight elevator, 8 feet by 10 feet, of 5000 lbs capacity. The elevators were to run from the launch pad to the top of the service structure. Elevators were to be automatic, push-button operated, and self-leveling with stations at the ground, each fixed and servicing platform, and at the derrick level.

F. Traction:

The traction drive system was to be of similar design to that of SATURN Service Structure No. I, except that AC traction motors were to be used. Speed range was to be $1\frac{1}{2}$ to 45 FPM with smoothly controlled acceleration, deceleration, and braking. Skew was to be minimized by use of mechanical squaring shafts. Because the lower legs were to be widely spaced and rail mounted, skew control was not deemed critical.

G. Anchoring and Guying:

The service structure was to be anchored at the parked position and at the launch pad. Hydraulic jacking could be used at anchoring positions to prevent Brinelling of the truck wheels; however, consideration was to be given to the feasibility of increasing the number of wheels sufficiently to allow the structure wheels to ride the tracks at all times.

The Service Structure was to be guyed at winds over 75 MPH under hurricane conditions.

H. Safety:

Structural configuration, platform design and elevator controls were to be such as to allow personnel to enter, work, and leave the service structure without physical mishap. Provision was to be made for safety railings, safety ladders, alarm systems, safety showers and eyewash fountains as required. Fire fighting equipment including water hoses, fog nozzles and portable CO_2 extinguishers was to be provided on all service platforms.

J. Replacement Time:

The initial concept for Launch Complex 37 provided only a single pad arrangement (fig. 18). The committee agreed that in event of catastrophe, such as an explosion at the launch pad with service structure - as well as the umbilical tower - would be destroyed, and the time required for replacement would be 12 months.

K. Umbilical Tower:

The umbilical tower was recognized as equal in importance to the service structure. The committee considered retractable and reclining designs of both articulated and pivoted types. Summary evaluation showed high cost and complex actuating systems as well as structural problems. The free standing umbilical tower with swinging arms was deemed best. The arms were to enter the platform enclosures through cutouts in the platform vertical mating edges. The umbilical tower base was to be a 3 story hardened building; it would house junction and servicing terminals for electrical, mechanical, hydraulic, instrumen-

tation and utility ground systems. The tower was to be positioned on the centerline of the service structure on the opposite side of the launch pedestal. Preferred clearance from vertical centerline of the launch pedestal to the tower near face was to be 40 ft.

L. Launch Pedestal:

Construction difficulties had been experienced with the concrete pedestal at LC 34; primarily in maintaining close tolerances of level for hold down arm bed plates. A launch pedestal constructed of steel plate was preferred. For gas and flame deflection of a 2 to 3 million pound thrust vehicle the height of the pedestal was tentatively established at 35 feet and top deck was selected at 50 ft. square. The flame deflector was to be rail mounted for removal and repair.

M. Initial LC 37 Site:

The first arrangement of Complex 37 provided only a single launch pad (Fig. 19). The launch pad was to be 500 ft. diameter and the flame deflector was to discharge northwest and south

east. For launching, the service structure was to park some 800 ft. northwest of the launch pad on pad side of the Operations Support Building. Firing azimuth was to be in the easterly sector 44 to 100°E. Rocket Fuel, Liquid Hydrogen, and Liquid Oxygen ready storage facilities were to be in separate quadrants. To preserve the necessary lines of sight, the layout was arranged with the blockhouse at safe distance north of the pad. A cableway was to run from the blockhouse to the base building of the Umbilical Tower; that section at the launch pad was to be a subterranean tunnel.

VIII. THE SECOND PAD FOR COMPLEX 37

The initial R&D phase of SATURN program was planned for execution on Complex 34. Should a flight abort explosion occur on Complex 34, rebuilding time was estimated at 12 months minimum. Complex 34 was being constructed for first generation vehicles having $1\frac{1}{2}$ million pounds thrust; second generation vehicles were originally conceived at 2 to 3 million pounds thrust and were planned for launching from Complex 37. Because of reconstruction time, it was desirable to incorporate in Complex 37 the capability for first generation vehicles as well as that for the second generation vehicles; this would have provided some assurance that the program schedule could be maintained.

The idea developed that the 12 month reconstruction time could be reduced to 6 months if a second launch pad were provided; if the pad and buildings were limited to "brick and mortar", pad "outage" for Complex 37 would be limited only to the necessary outfitting time of 6 months. With a programmed increase in the planning schedule, this idea became firm.

The dual requirement for LC 37 to have launch

capability for both Saturn I and C-2 vehicles heavily influenced the site layout. SATURN I plans were becoming real vehicle hardware; umbilical arm positions were fixed. If SATURN I vehicles were to be launched from Complex 37, the umbilical tower/service structure relationship at Complex 37 had to be similar to that at Complex 34; any other arrangement would force manufacturing changes in configurations of SATURN I vehicles.

To maintain this required relationship, lines of sight to ground instrumentation and control stations had to be preserved (Fig. 5) for the required prelaunch "lock on". Where as the single pad plan readily circumvented this problem, the duplex pad arrangement had to be subjected to a rather intensive study, for either a separate service structure had to be provided for each pad or a rail track transfer system had to be installed. Trackage on concrete rail beams was known to cost $700 to $1000 per foot; and service structures to cost 5 million dollars or more.

Variations in the track arrangements were compared for both 3 and 4 track systems, (Fig. 20). Although the directional orientation of the structure can be preserved with the curved systems, the lateral transfer

straight track system proved definitely more economical.

The first duplex pad concept (Fig. 21) for LC 37 was therefore quite different than the single pad concept, (Fig. 18).

The service structure was to be parked at the launch pedestal which was not in use. Satisfaction of the line of sight requirement and the SATURN I and LC 34 configuration relationship resulted in pad centerlines being on azimuths N 122°E. All required features for fuel and cryogenic storage, blockhouse, pad access roads, cableways, and the camera stations were satisfied.

The damage potential for an abort "on pad" explosion of SATURN I was originally calculated for RP-1/LO_2 propellant combinations. Examination of test results and recalculations of separation distances required for SATURN C-2 propellants employing LH_2 in the upper stages showed a need for pad separation of 1200 feet in lieu of the previously selected 650 feet. With this 1200 ft. separation, the launch pad layout was revised (Fig. 22). Since design was already underway, the off-center unsymmetrical arrangement resulted. This was the Final Criteria Plan from which Launch Complex 37 was designed.

IX. THE REAL MACHINE

With these concepts and plans as background, criteria resulting in the real SATURN Service Structure was prepared. The firm of Maurice Connell and Associates was selected as the Architect Engineers; under the able direction of Mr. Harvey Pierce, the final plans and specifications were developed from an extensive design analysis. The REAL MACHINE as it exists today is shown in Fig. 23. Mr. Pierce can tell you better than I of its design development.

TABLE I

SATURN C-2 VEHICLE CONFIGURATIONS

		COMPONENT STAGES			
Scheme	Booster	Second Stage	Third Stage	Fourth Stage	Fifth Stage
a	S-I	S-II	S-IV	S-V	SP**
b	S-I	S-II	S-III	S-IV	SP**
c	S-I	S-II	S-III*N	SP**	--

* Nuclear; for information only.

** Spacecraft or Payload

TABLE II

DIMENSIONS AND WEIGHTS
OF
SATURN C-2 COMPONENT STAGES

Vehicle Stage	Diam. Inches	Length Feet	Weight (dry) lbs	Spacecraft Capability, Lbs.
S-I	260	78	89000	
S-II	260	72	25000	45000
S-III	260	52	20000	55000
$S\text{-}III_{N}$*	260	145	30000	55000
S-IV	220	43	11000	55000
S-V	120	31	5000	

* Nuclear; for information only.

TABLE III
MANDATORY OPERATING CLIMATE
(External Exposure)

GENERAL DESCRIPTION

Climate	Typical Sub-tropical temperate zone
Location	Seaside
Sun Exposure	Severe
Dew	Subject to heavy deposits daily
Fog	Frequent subjection, salt laden
Ocean Spray	Frequent subjection
Sand	Frequent subjection, blowing

CCMTA WEATHER

Temperature:	
Maximum	95° FDB, 82° FWB
Minimum	32° FDB, 20° FWB
Average Daily Variation:	
Hot	17 F
Cold	10° F
Humidity:	
Maximum High	82° F Saturated
Maximum Low	33° F Saturated
Sun Load, Normal to Ray	310 BTU/SF
Latitude	28 Deg. N.

WIND LIMITATIONS

Wind Speed, Knots	Operation or Equipment	Action
0 to 40	Normal Operation	Continued
	In-service firing	Attempted
40 to 55	Checkout & Prefiring	Continued
	Apparatus & Missile	Lightly secured
	Firing	Not attempted
	Auxiliary Protective Devices	In service
	Hurricane Equipment	Ready for service
55 to 75	Checkout & Prefiring	Stopped
	Hurricane Equipment	In service
	Apparatus & Missile	Secured
75 to 125	All Operations & Equipment	Full Hurricane Duty

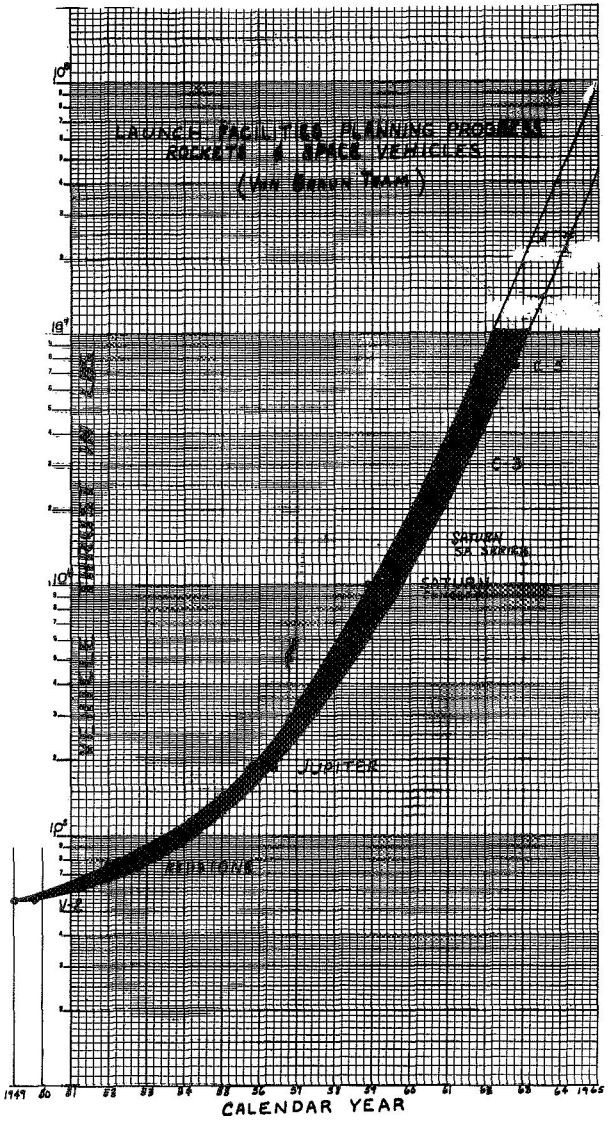


Fig. 1-A Facilities Planning Progress (Von Braun Team, Plot Vehicle Thrust vs. Time).

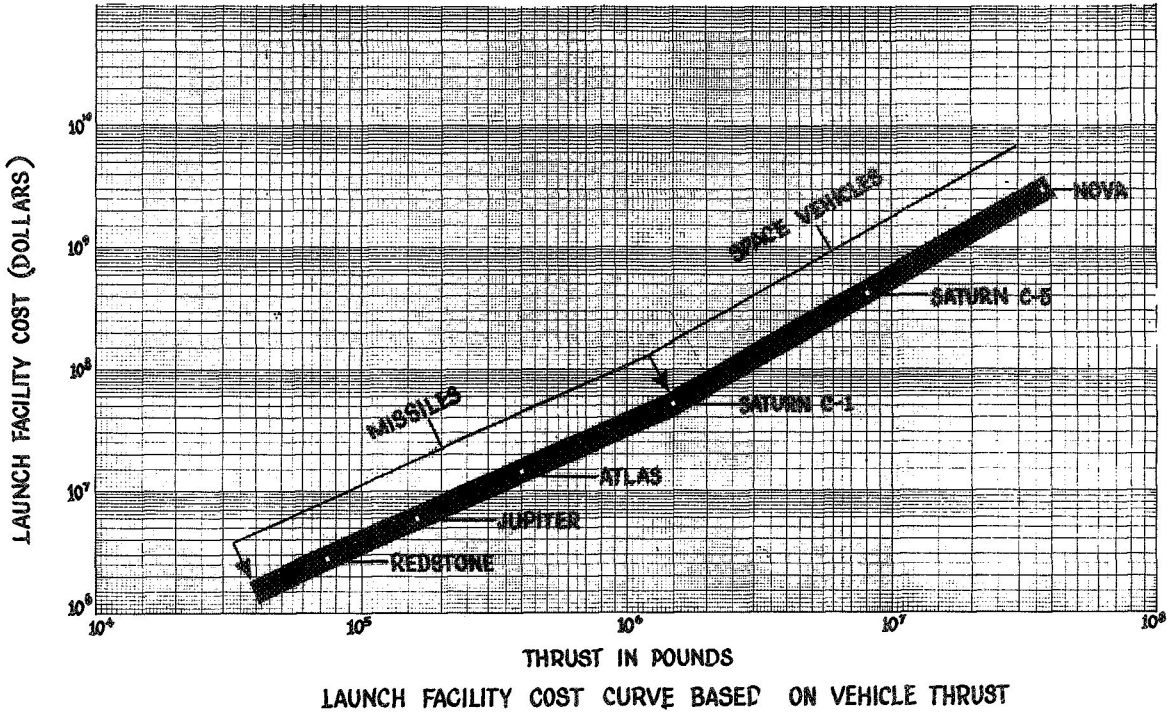


Fig. 1-B Facility Costs (Plot of Cost vs. Vehicle Thrust)

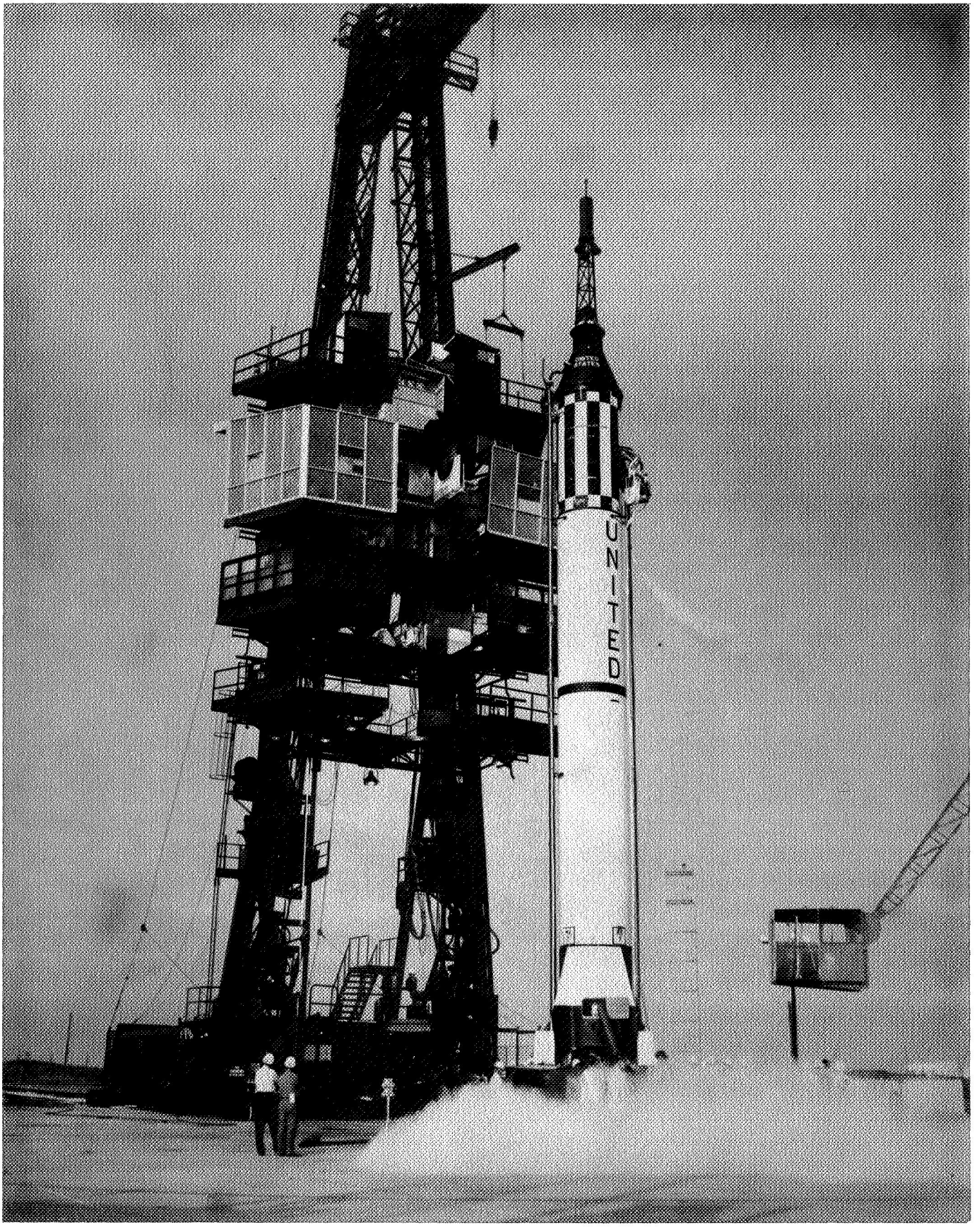


Fig 2 REDSTONE-MERCURY Space Vehicle with Redstone Service Structure No. 1, REDSTONE Launch Complex 5/6

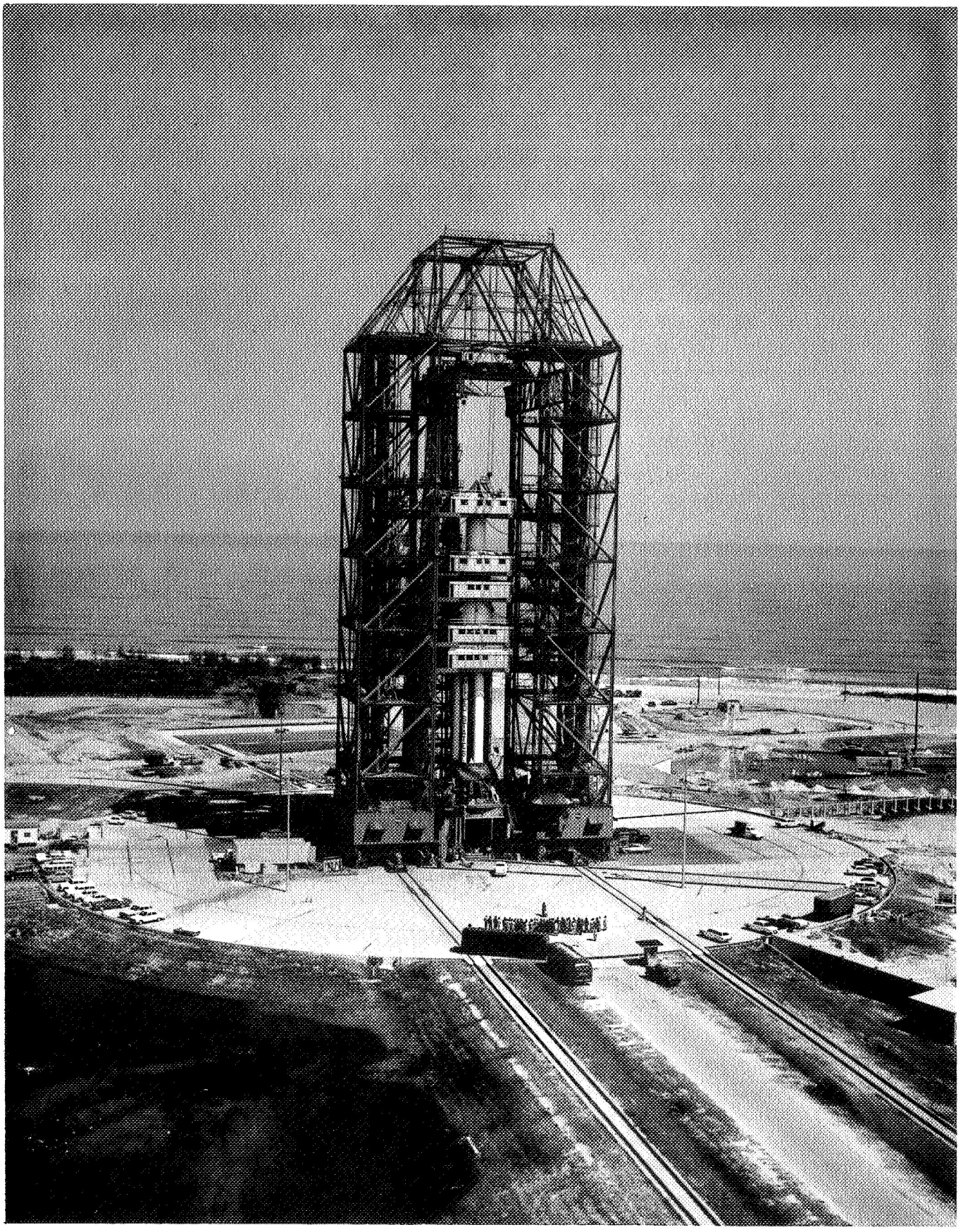


Fig. 3 SATURN Service Structure No. 1
SATURN Launch Complex 34

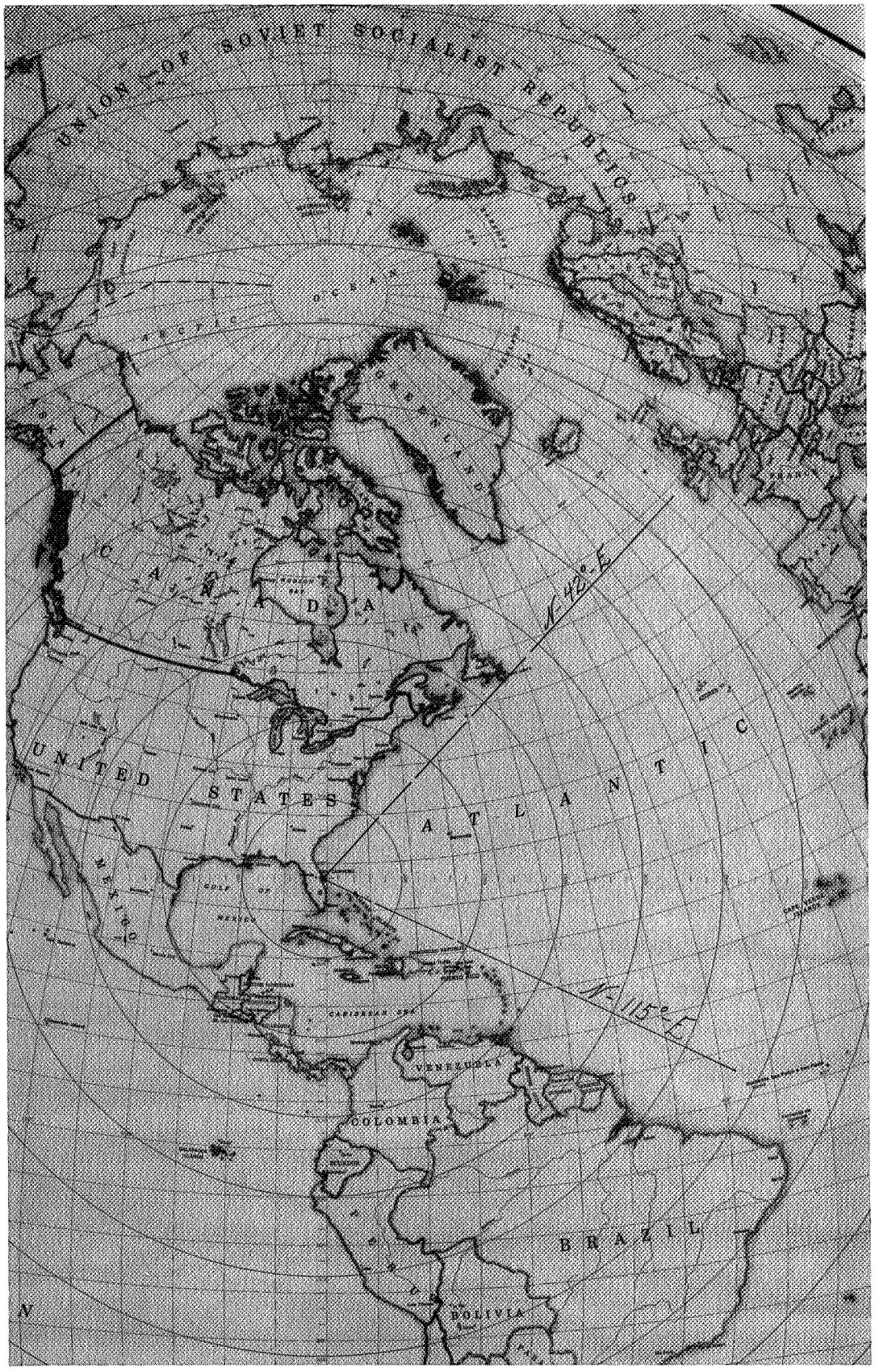


Fig. 4 FIRING SECTOR of Atlantic Missile Range, Polar Plot Map, (Canaveral Pole Point)

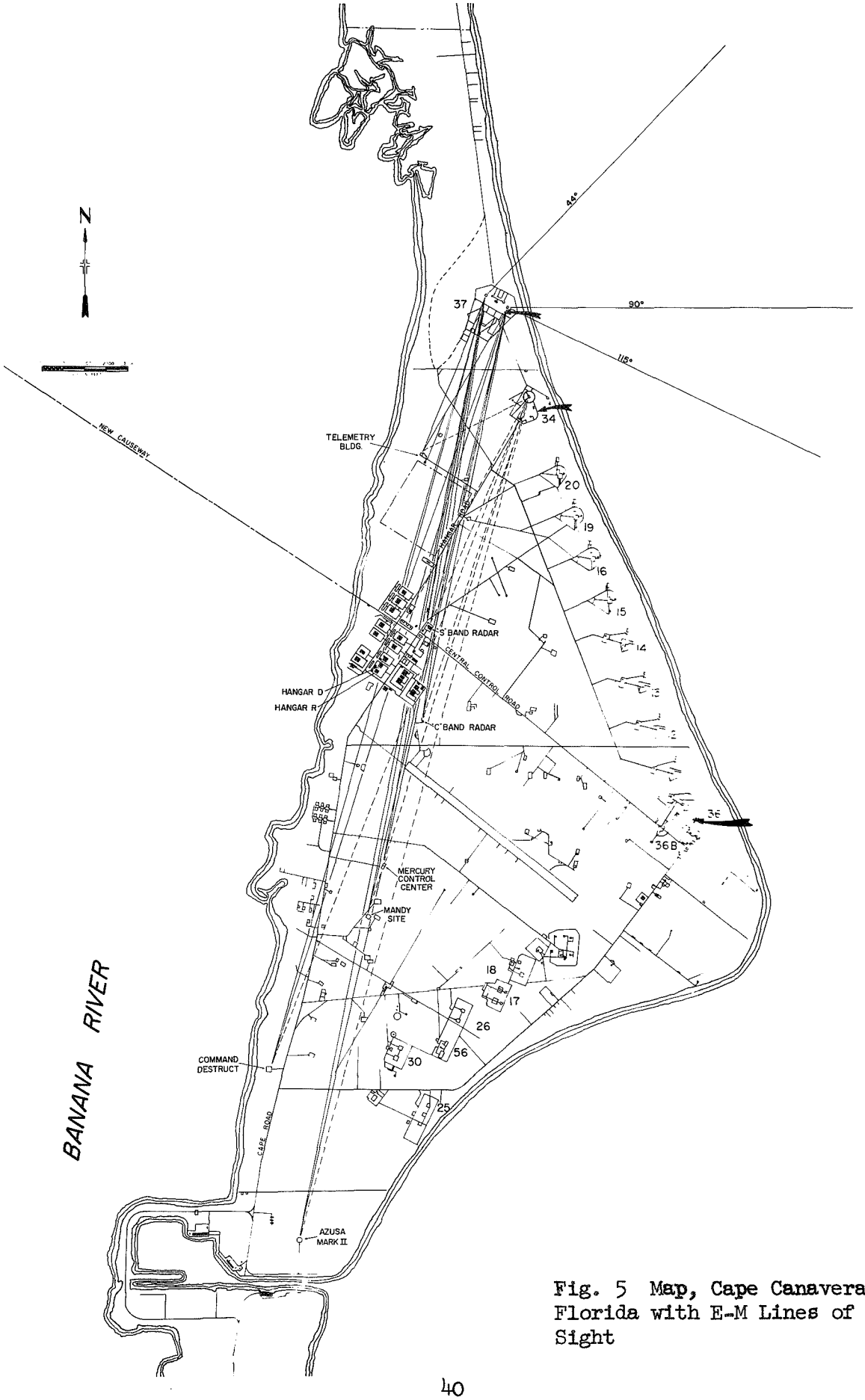


Fig. 5 Map, Cape Canaveral, Florida with E-M Lines of Sight

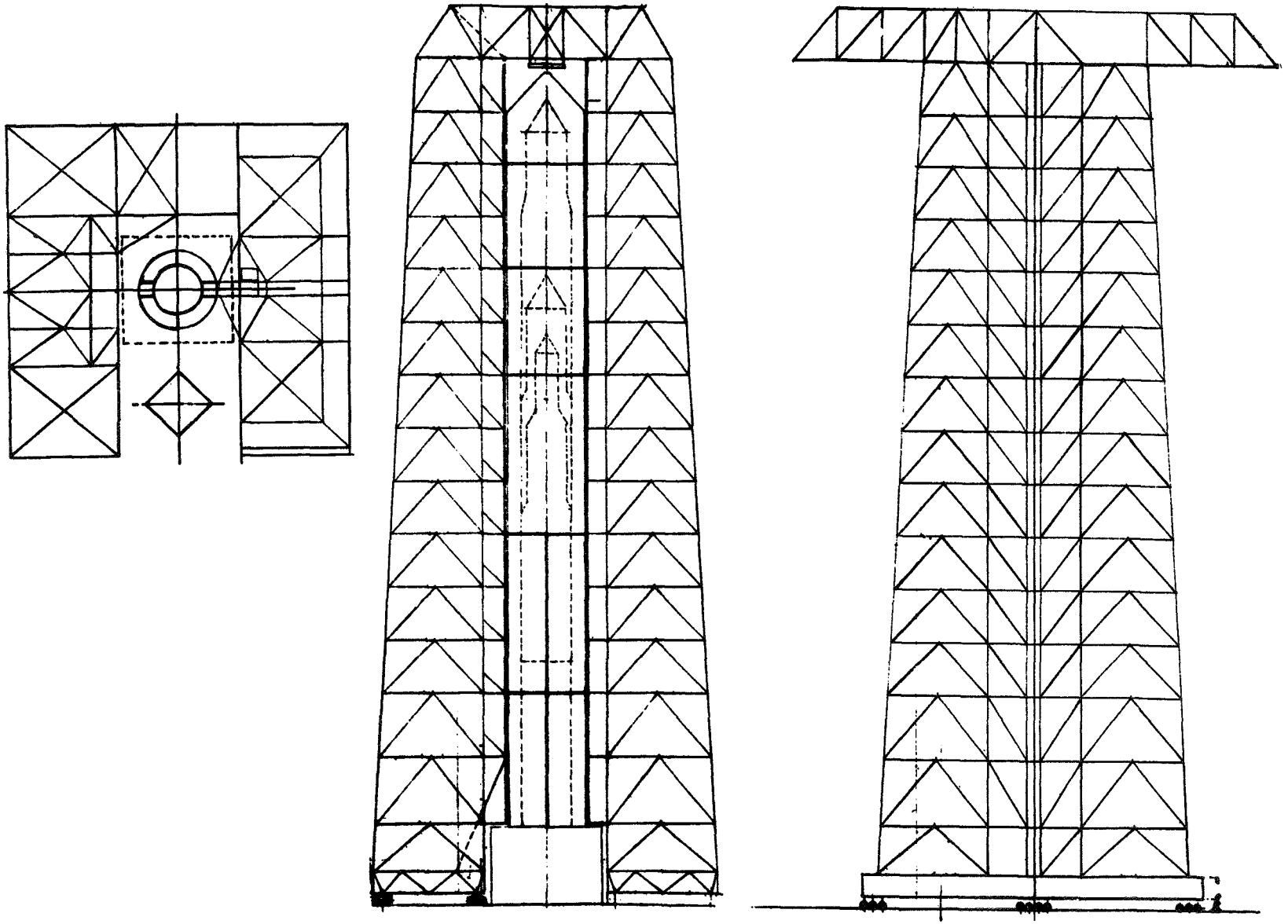


Fig. 6 Inverted "U/C" Frame Structure with Cross Bracing

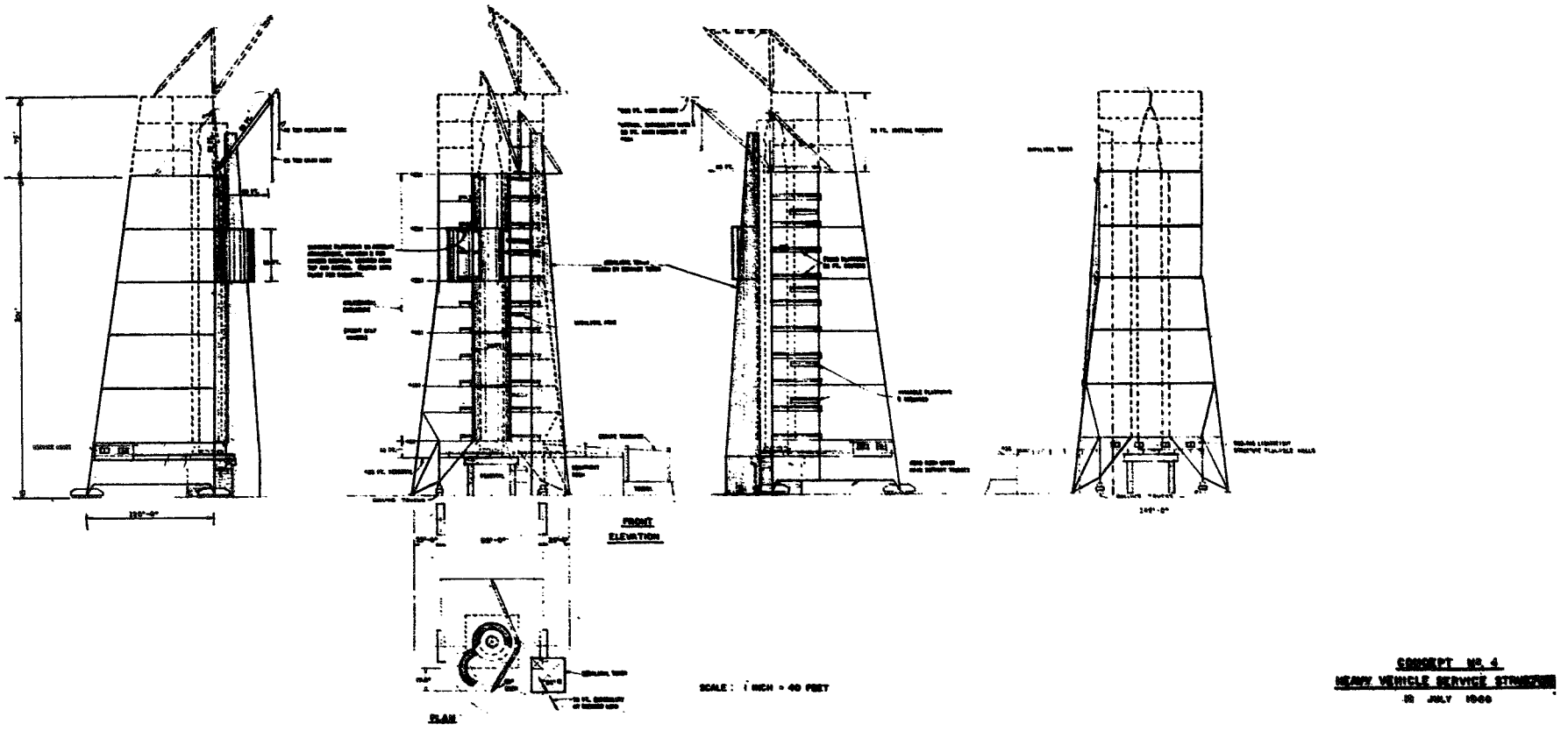


Fig. 7 Extensible TRAPEZOIDAL FRAME Structure, Swinging Enclosure

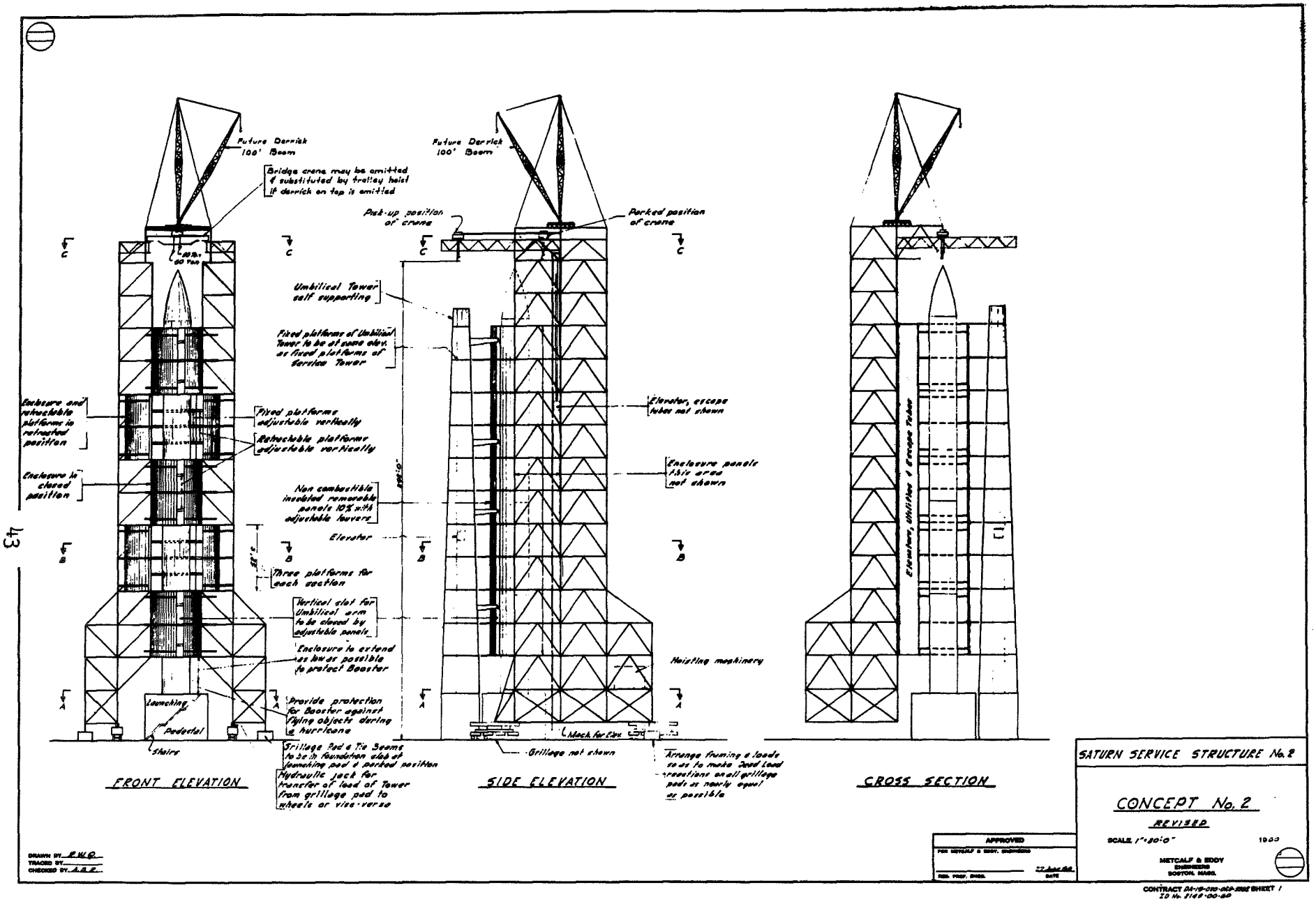


Fig. 8 Open Face "C" Frame Structure, Swinging Silo Gate Enclosures

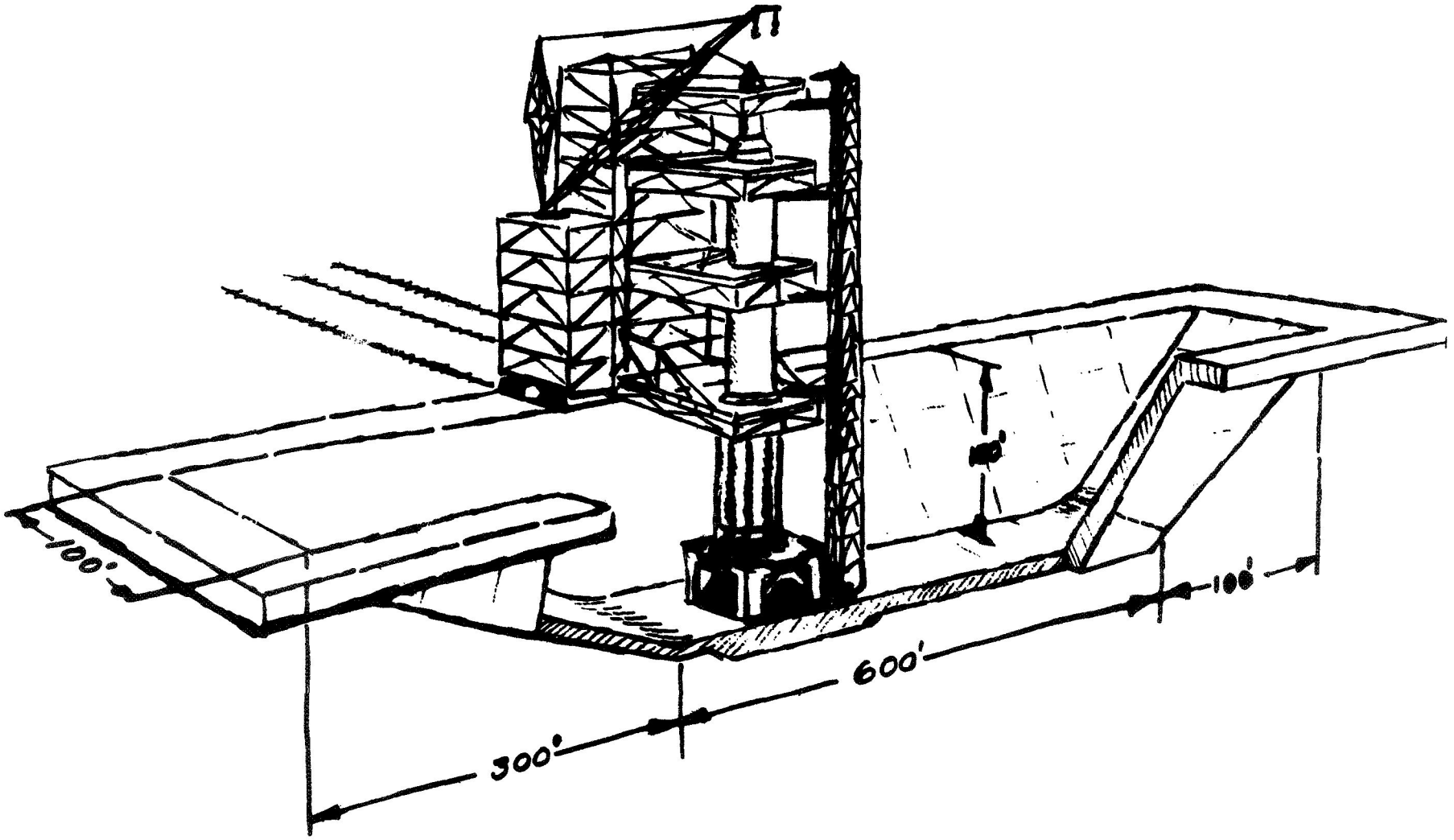


Fig. 9 Unique Retractable Service Structure with booster top at ground level
(Pedestal and Flame Deflector in Pit)

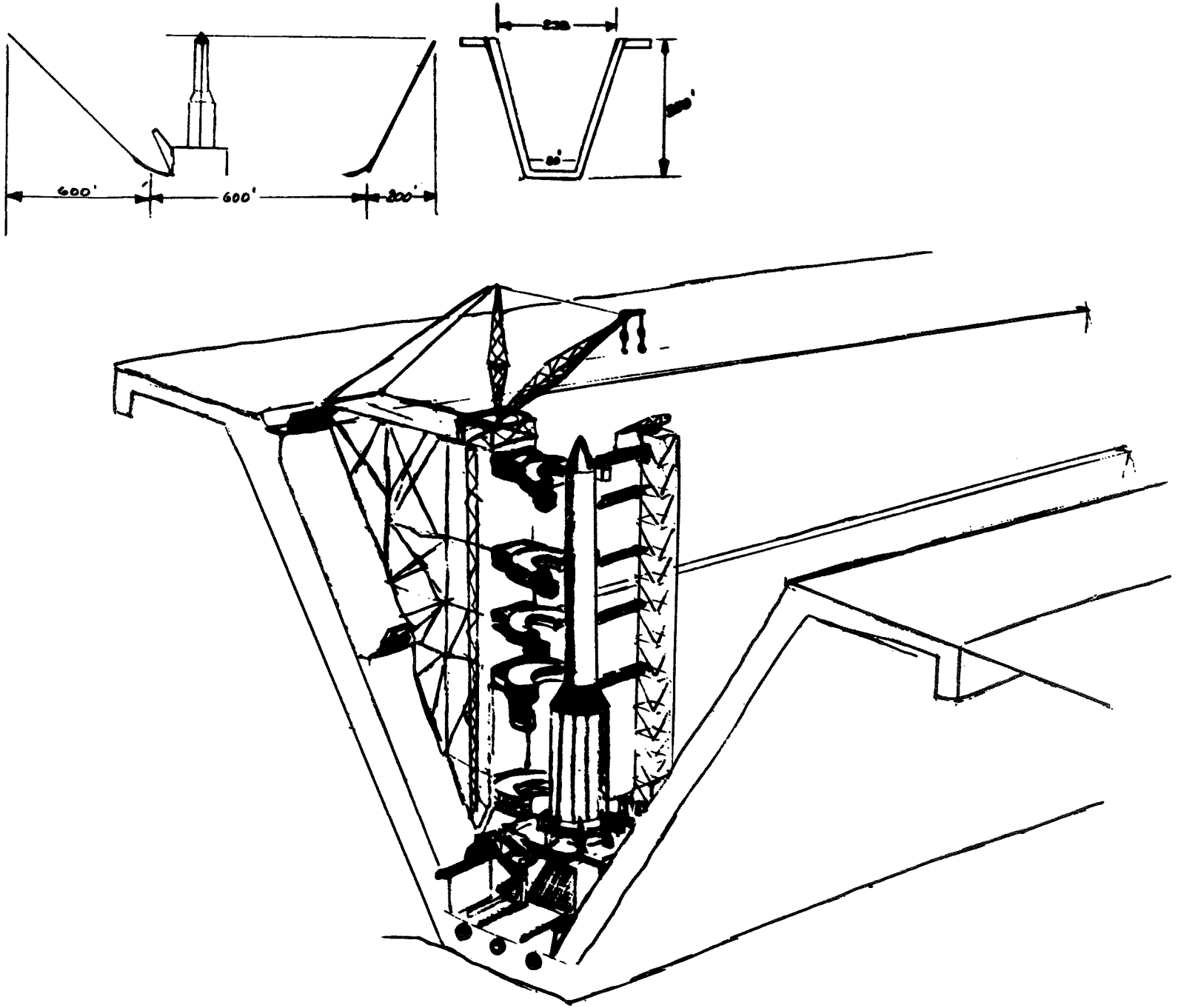


Fig. 10 Unique Fixed Service Structure with Top of Space Vehicle at Ground Level (Pedestal and Flame Deflector in Deep Well)

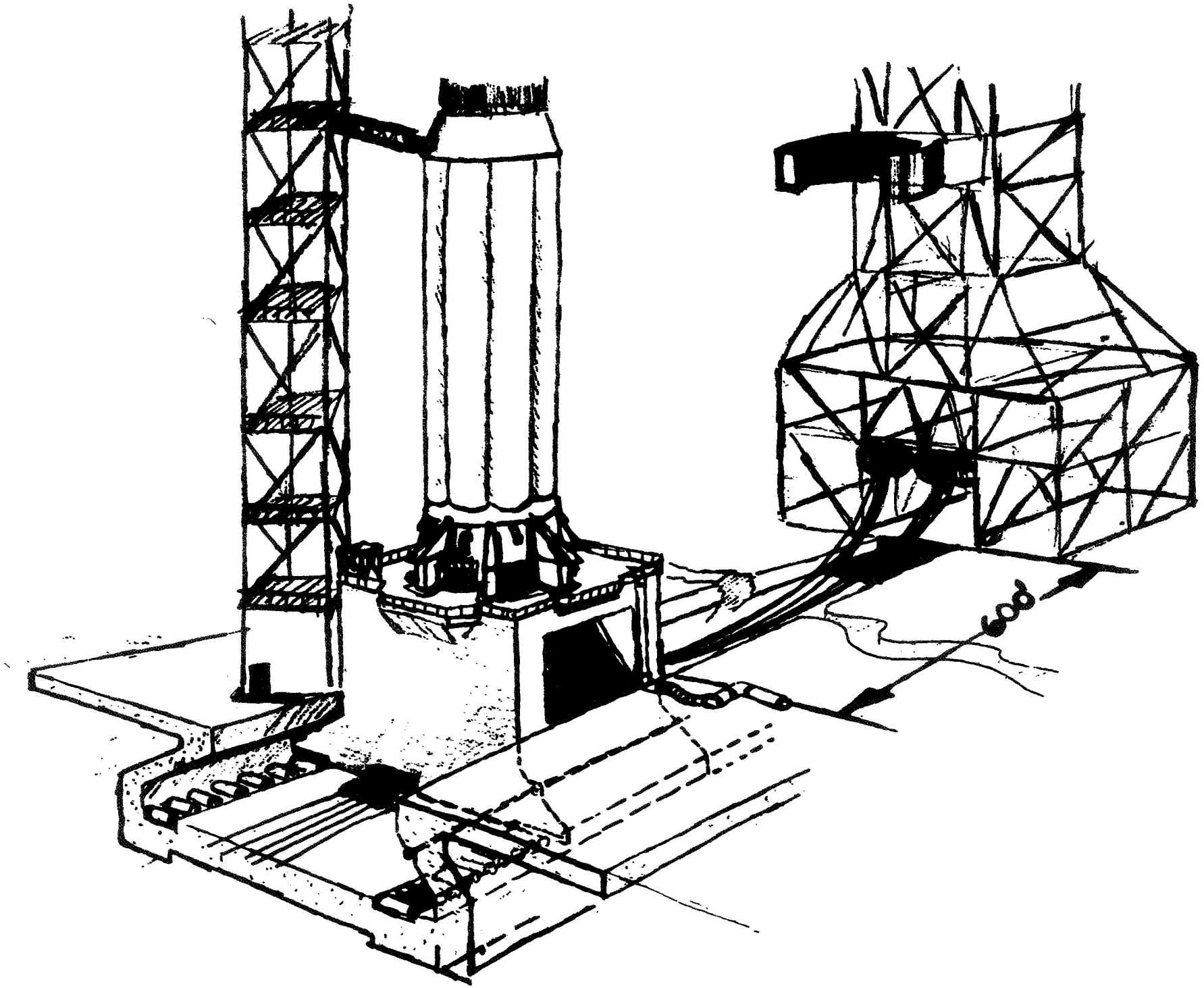


Fig. 11 Unique Moveable Launcher Pedestal and Flame Deflector with Fixed Service Structure

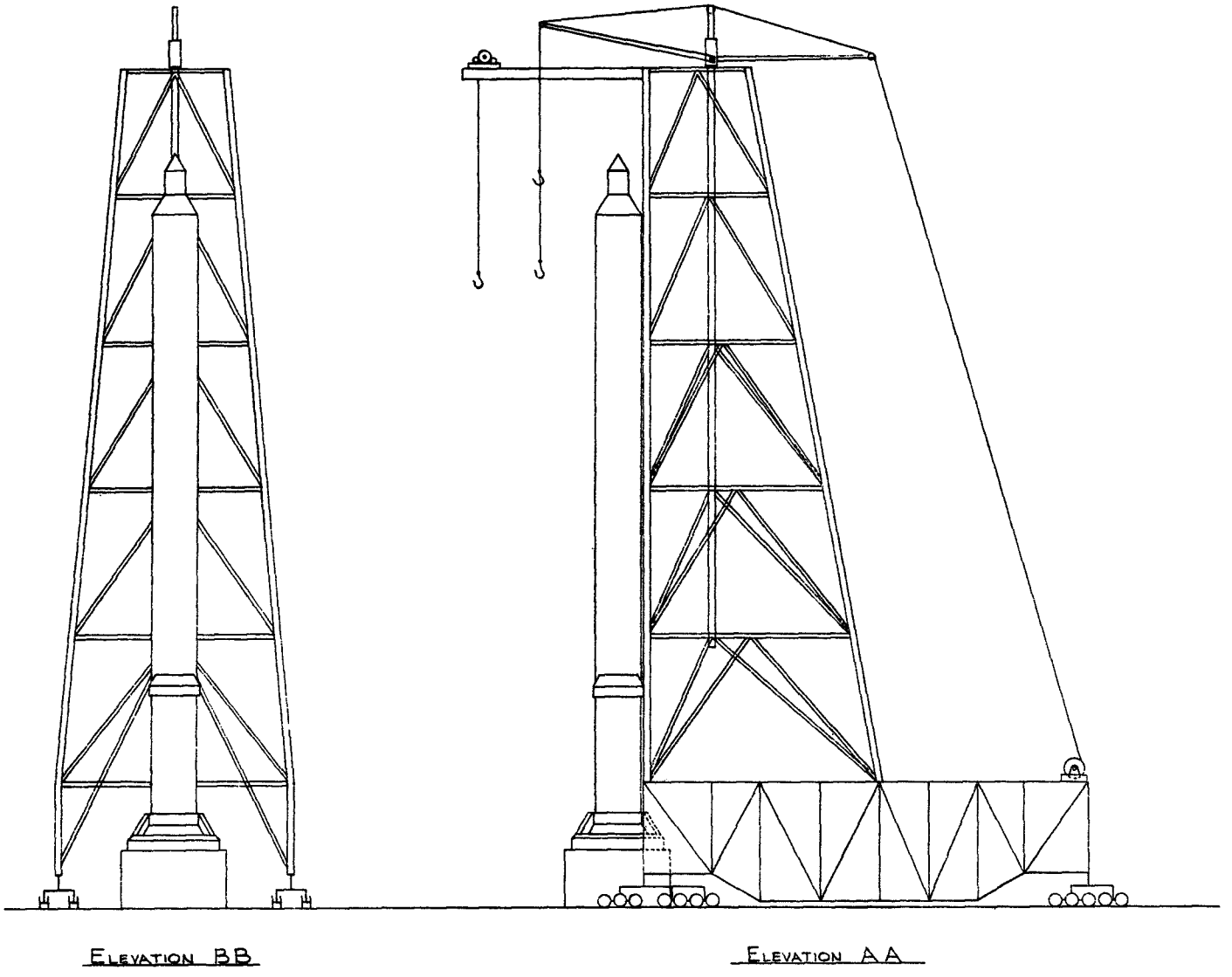
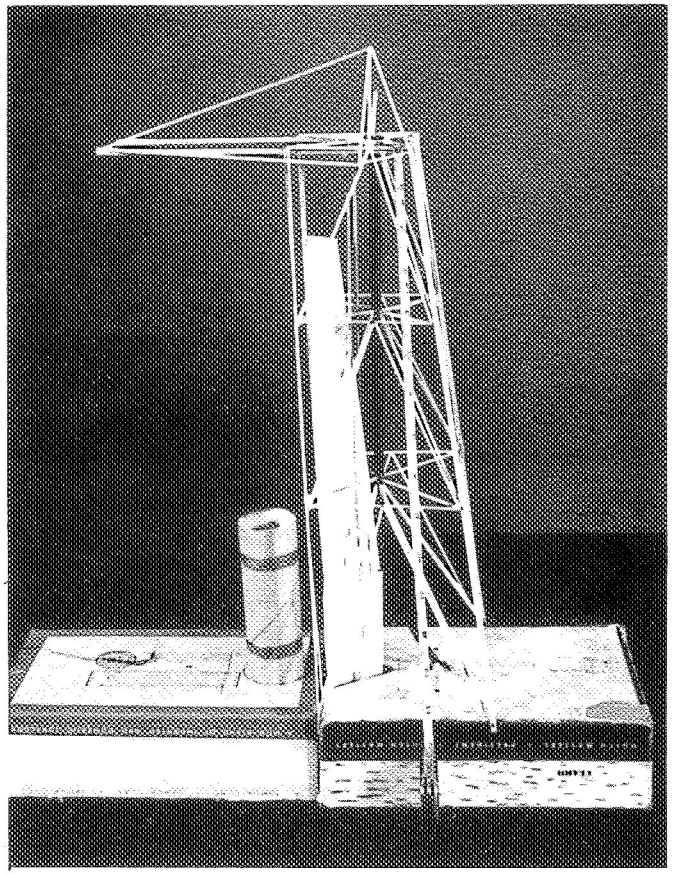
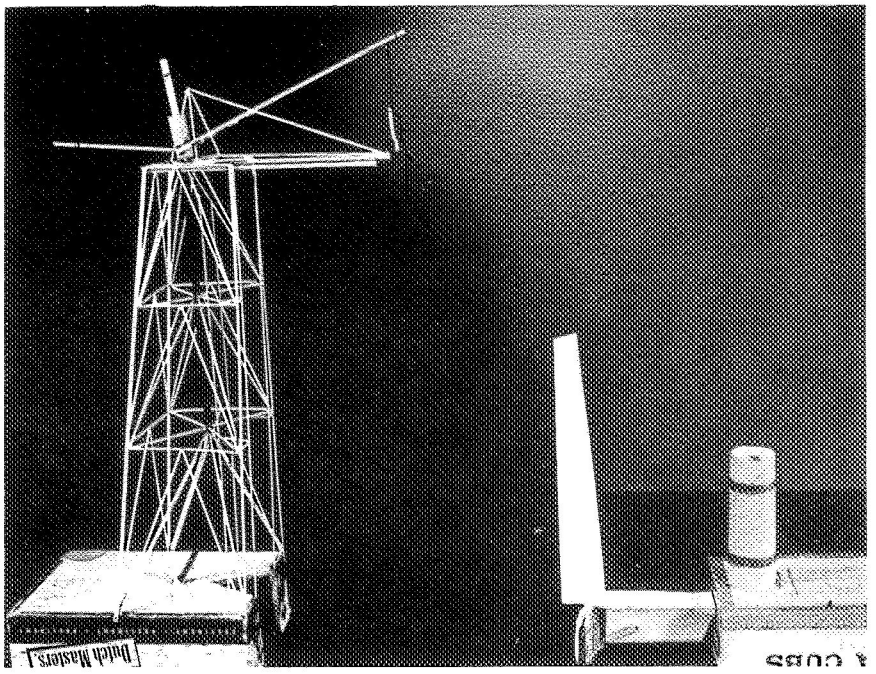


Fig. 12 Vertical, Open Faced, TRAPEZOIDAL FRAME SERVICE STRUCTURE (TETRAHEDRON SPACE FRAME)





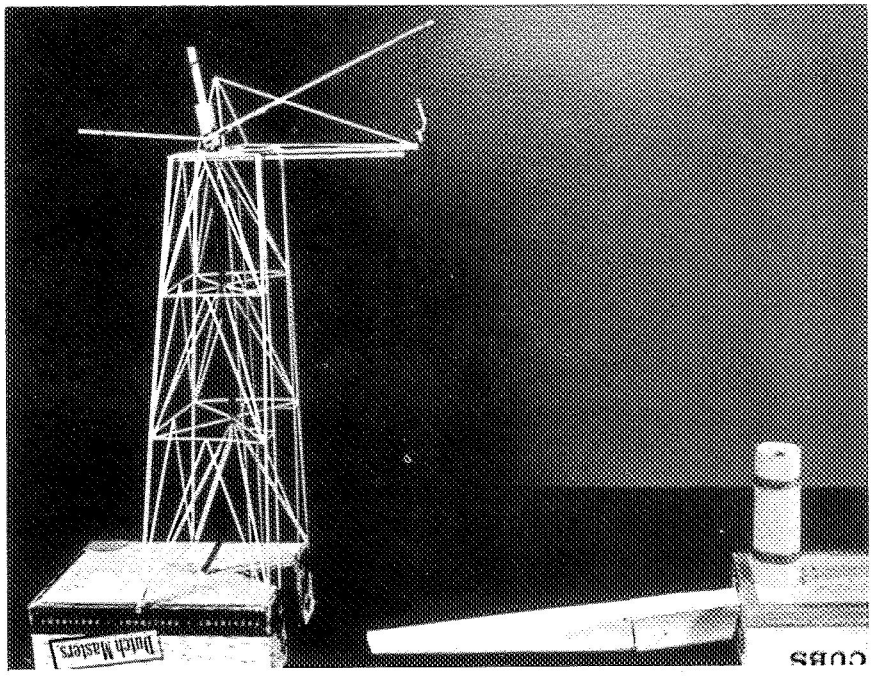


Fig. 13 First Model of Vertical, Open Faced, Trapezoidal Frame Service Structure with Reclining Umbilical Tower

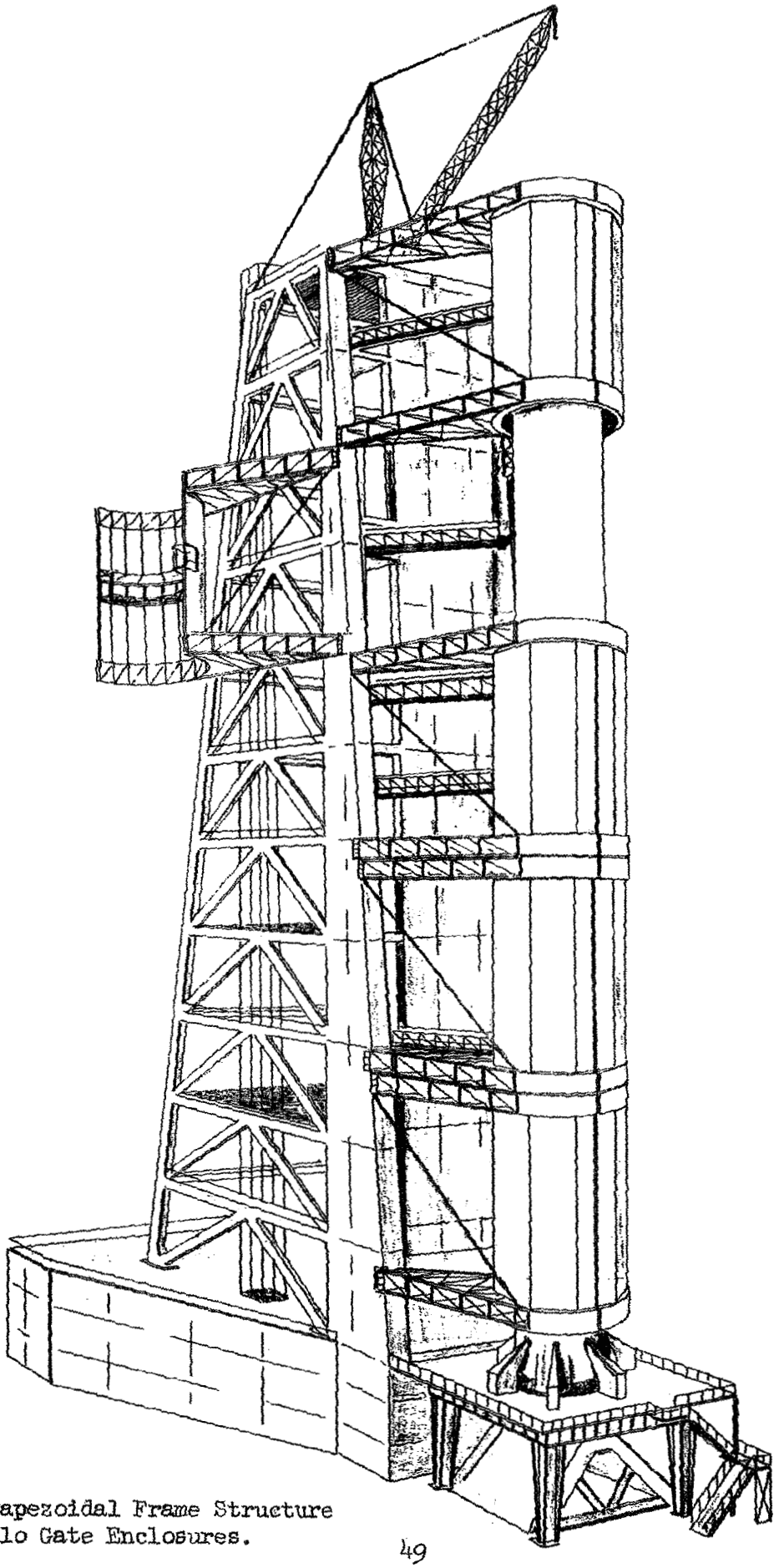


Fig.14 Fixed, Trapezoidal Frame Structure with Swinging Silo Gate Enclosures.

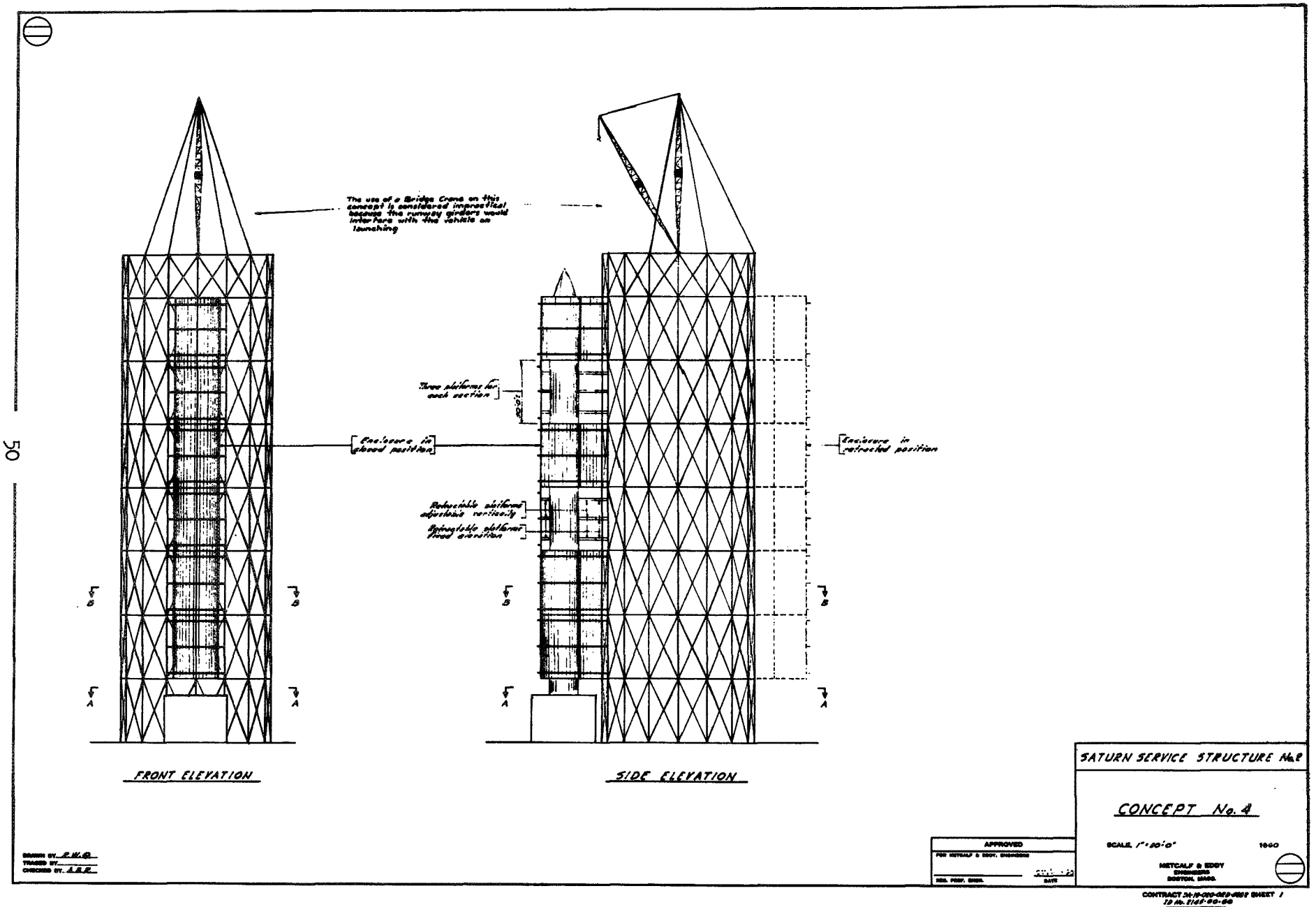


Fig. 15 Open, Single Column, Cylindrical Cage Frame, Fixed Structure with Silo Gate Enclosure

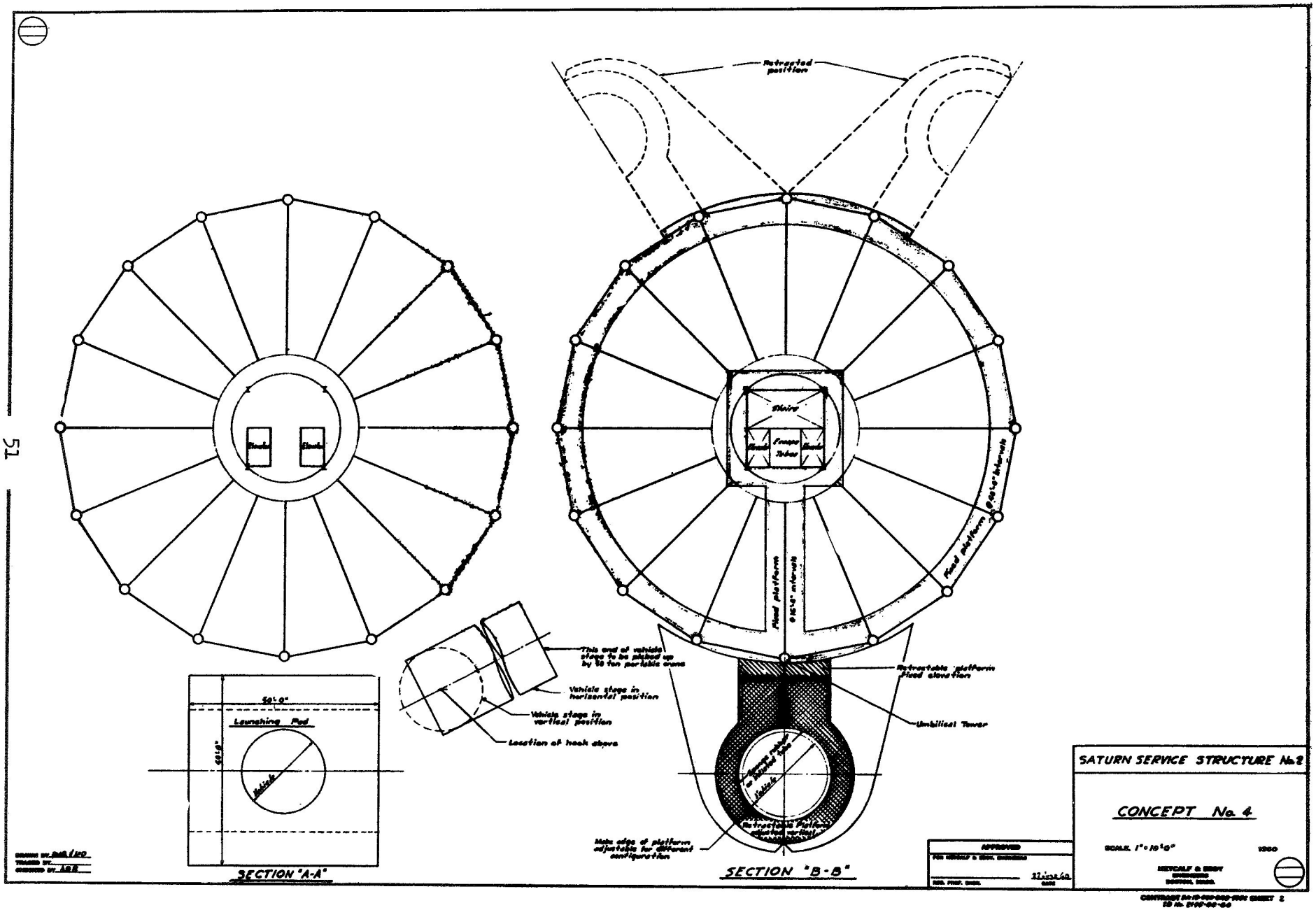


Fig. 16 Typical Platform Plans for Open, Single Column, Cylindrical Cage Frame, Fixed Structure

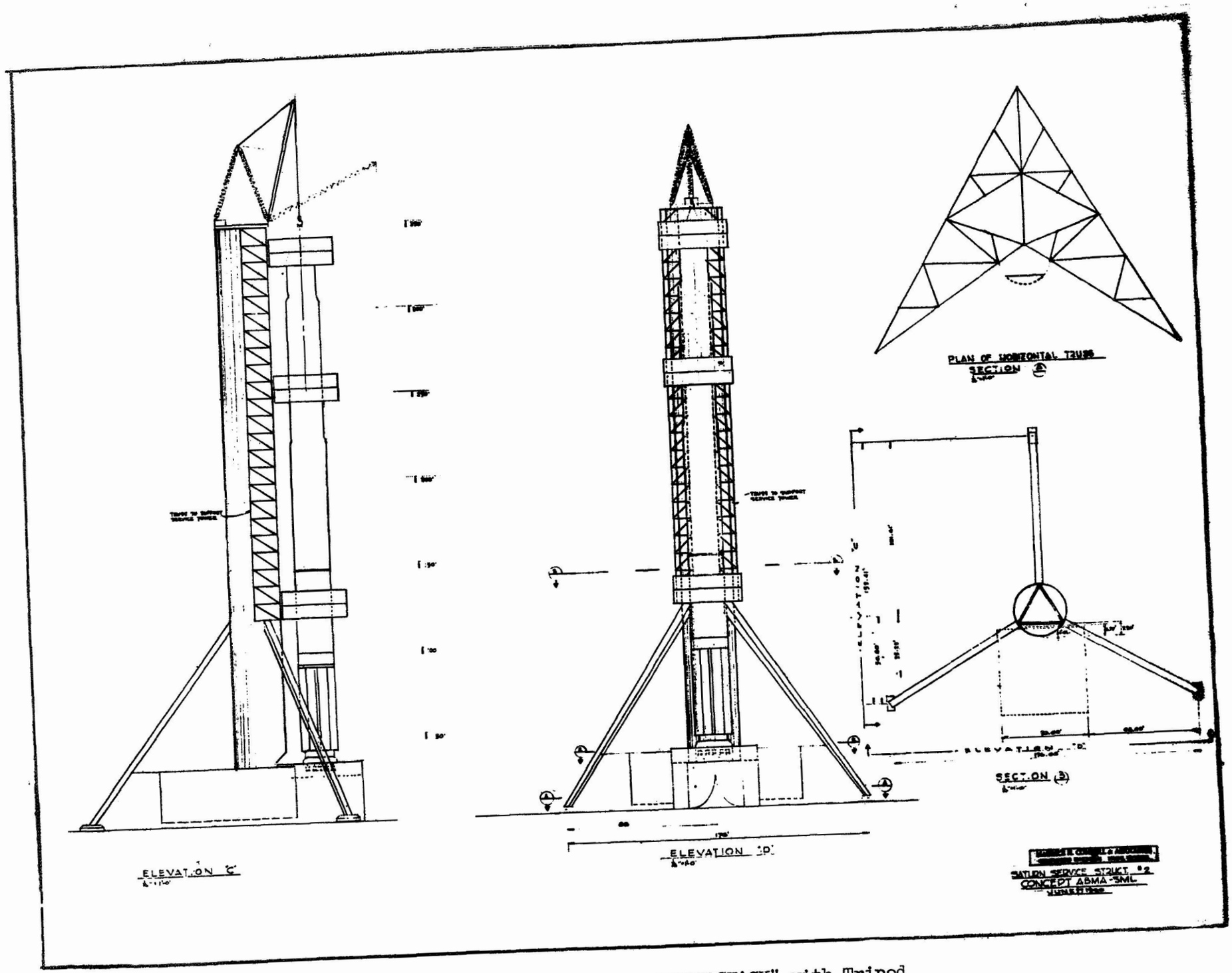


Fig. 17 Fixed Cylinder "SMOKESTACK" with Tripod

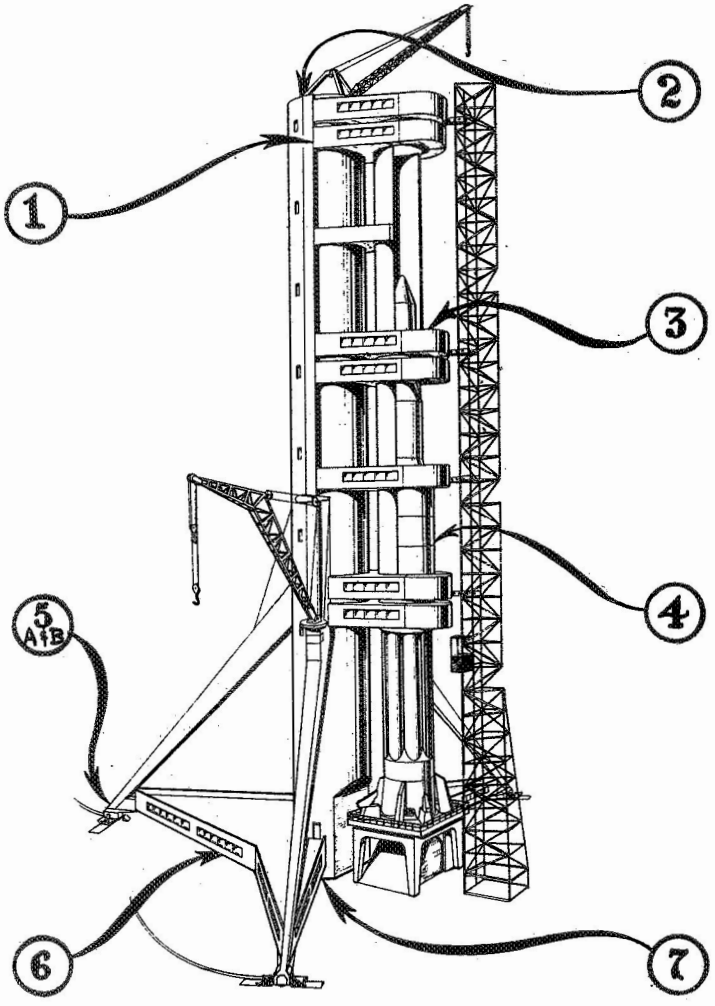
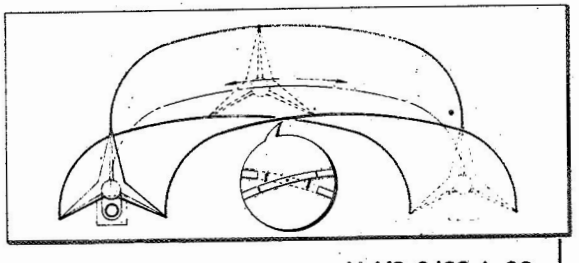


FIG I



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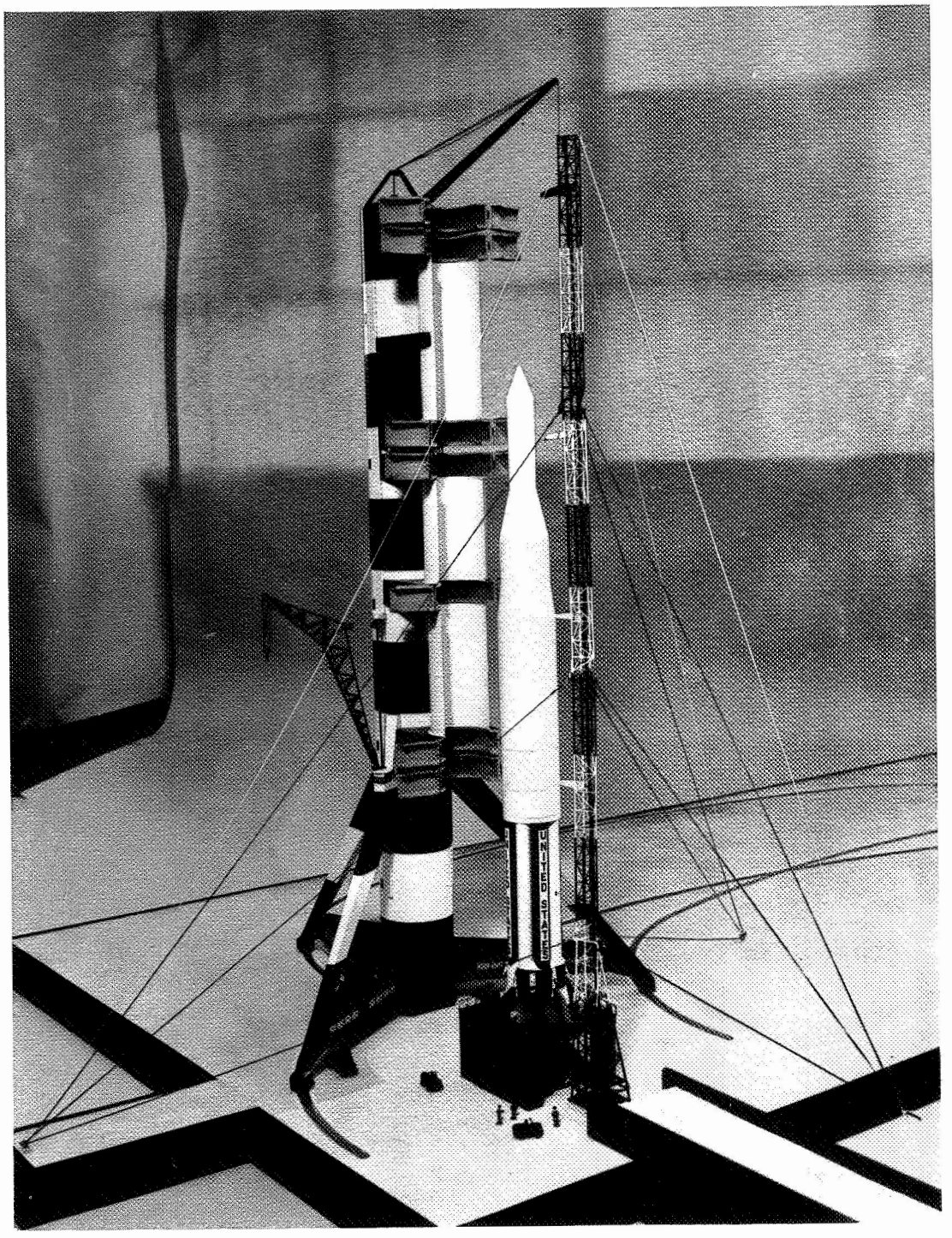
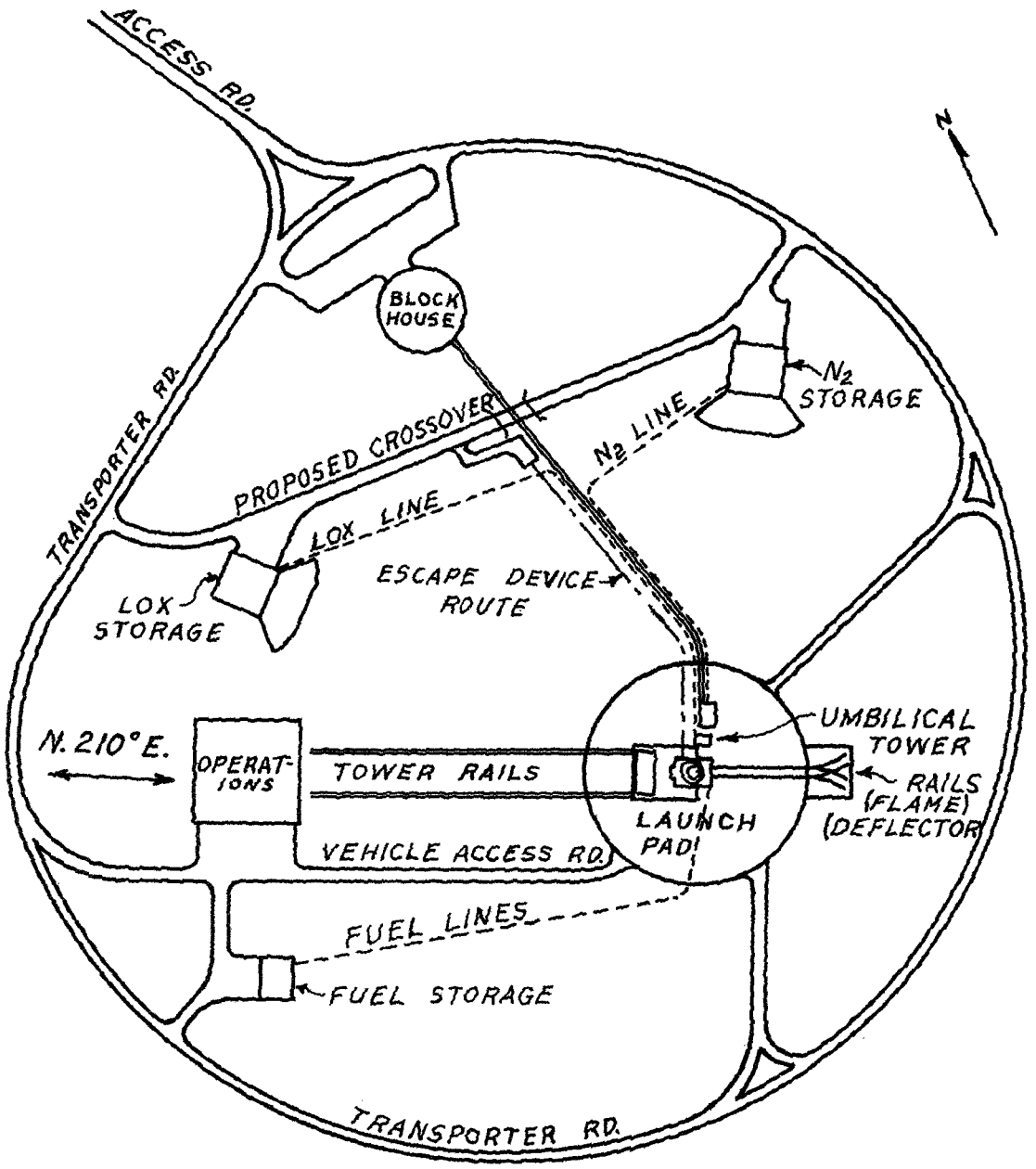


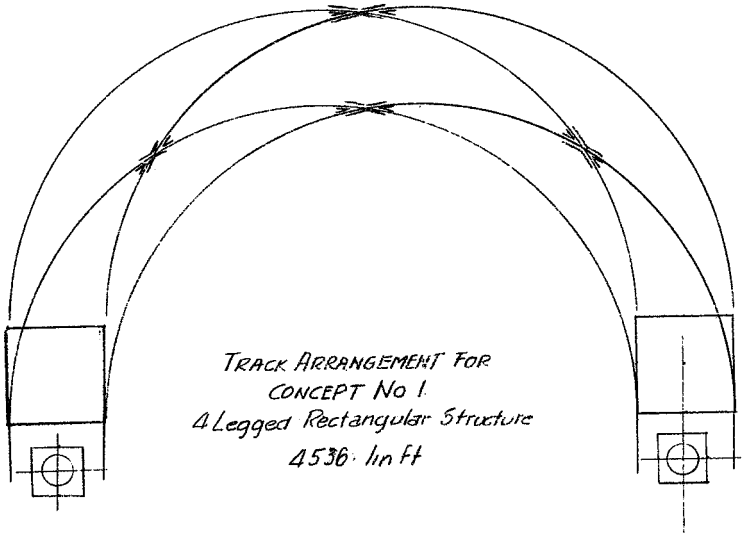
Fig. 18 Moveable Cylinder "SMOKESTACK" with Tripod Truck Mounting



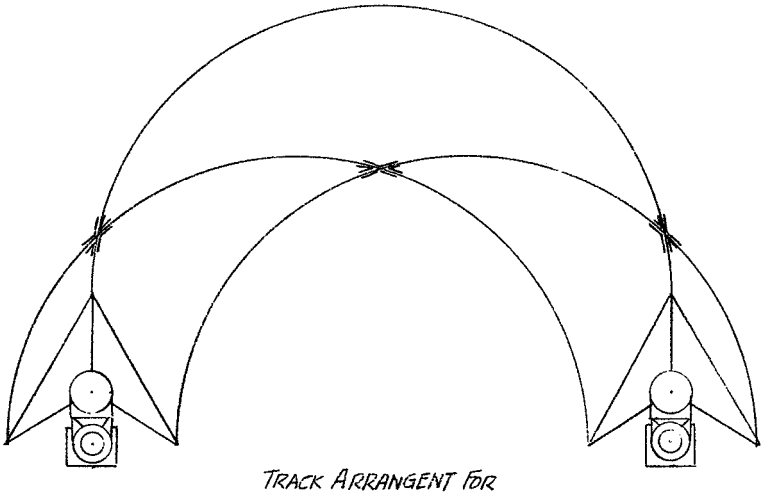
PROPOSED COMPLEX LAYOUT

Fig. 19 First Proposed Layout, Saturn Launch Complex 37

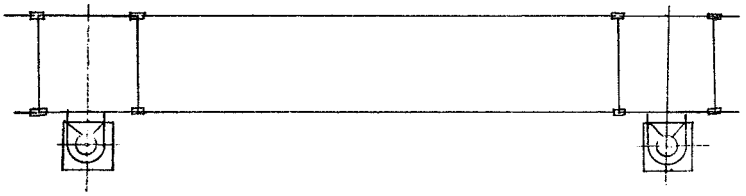
Fig. 20 Comparative Rail Track Arrangements for Single Service Structure Serving Duplex Launch Pads.



TRACK ARRANGEMENT FOR
CONCEPT No 1.
4 Legged Rectangular Structure
4536 lin ft



TRACK ARRANGENT FOR
CONCEPT No 2
3 LEGGED CYLINDRICAL
STRUCTURE
2827 lin ft



TRACK ARRANGEMENT FOR
CONCEPT No 3.
4 LEGGED RECTANGULAR STRUCTURE
1520 lin Ft.

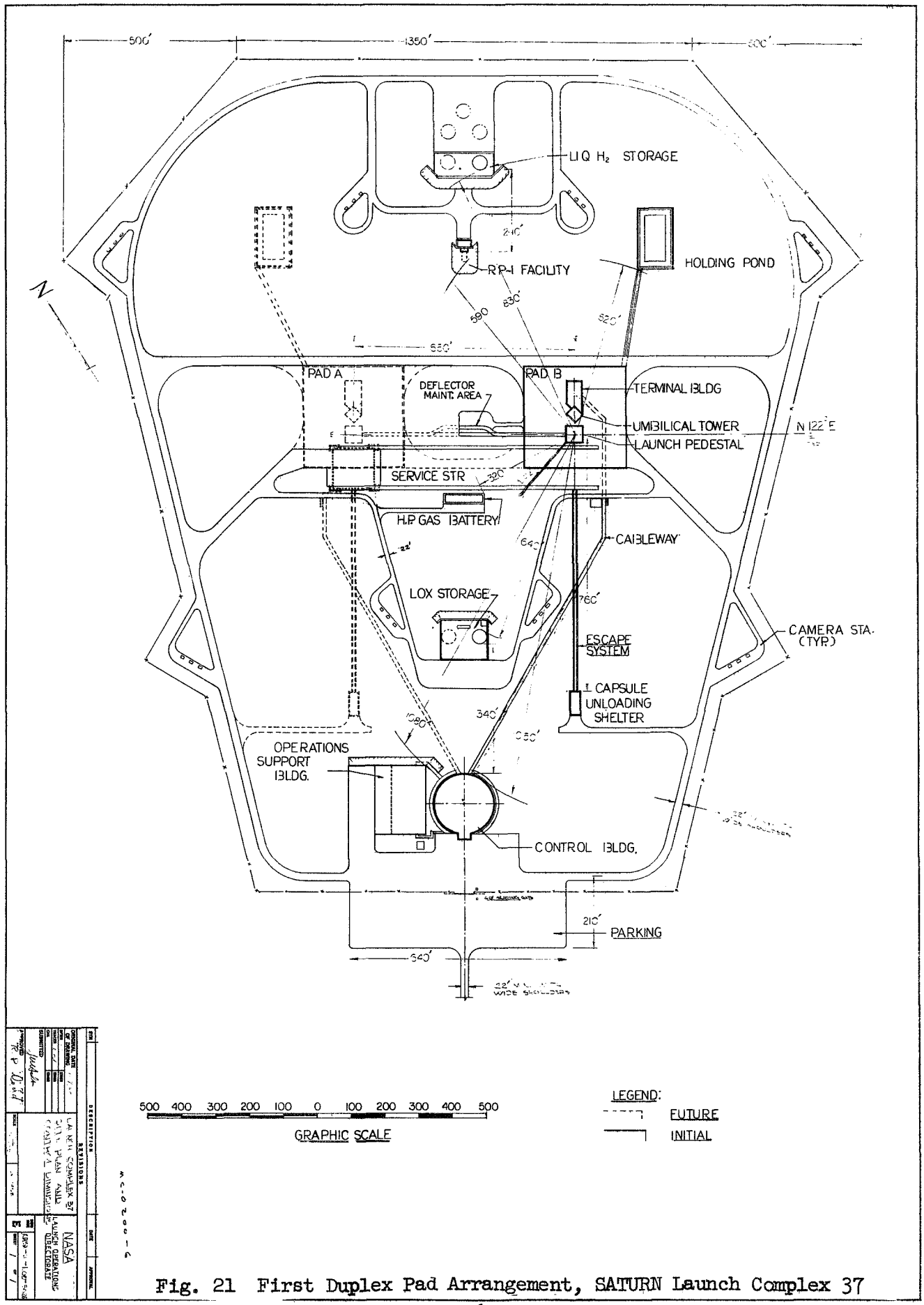


Fig. 21 First Duplex Pad Arrangement, SATURN Launch Complex 37

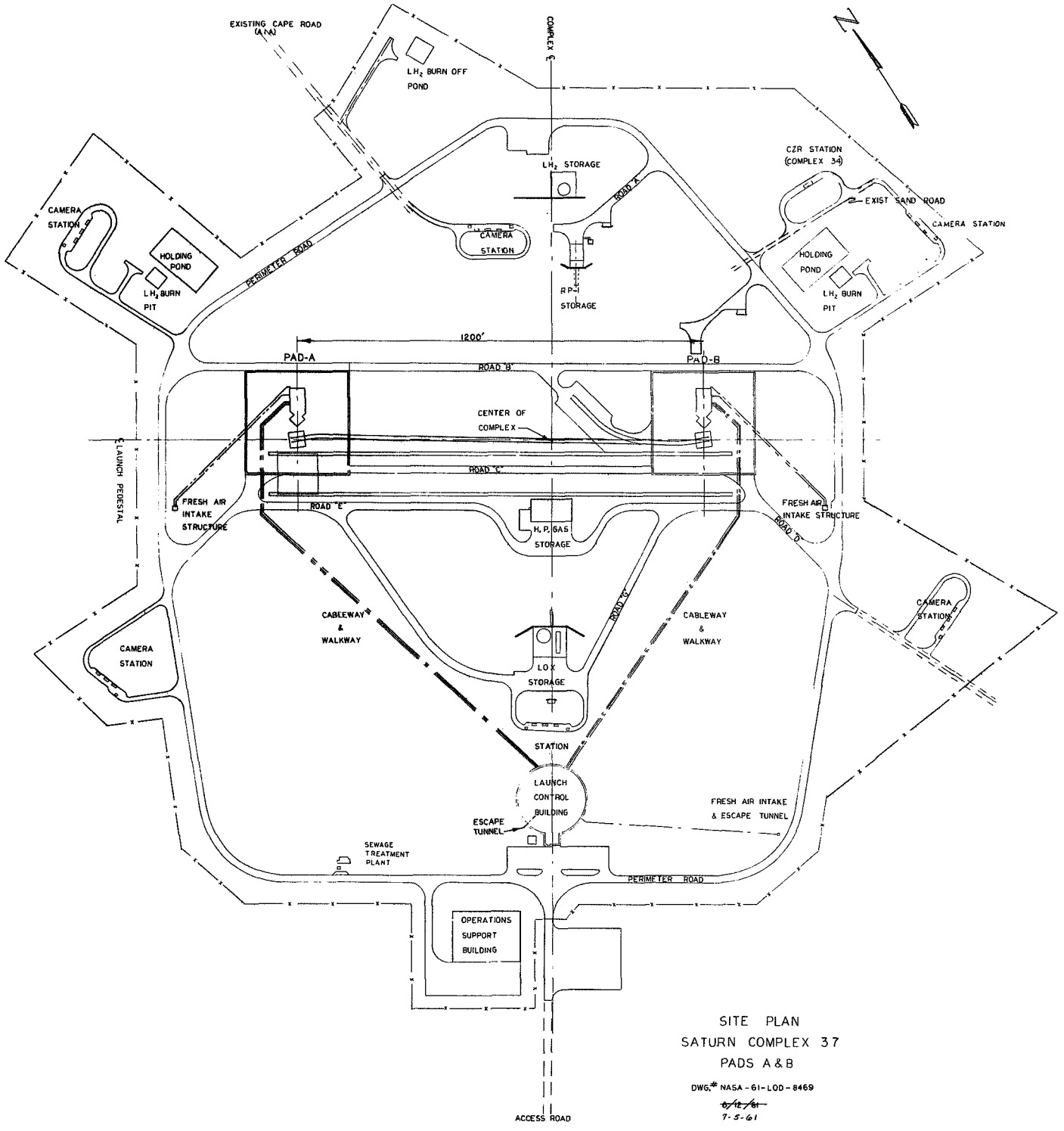


Fig. 22 Final Criteria Layout Duplex Pad Arrangement, SATURN Launch Complex 37

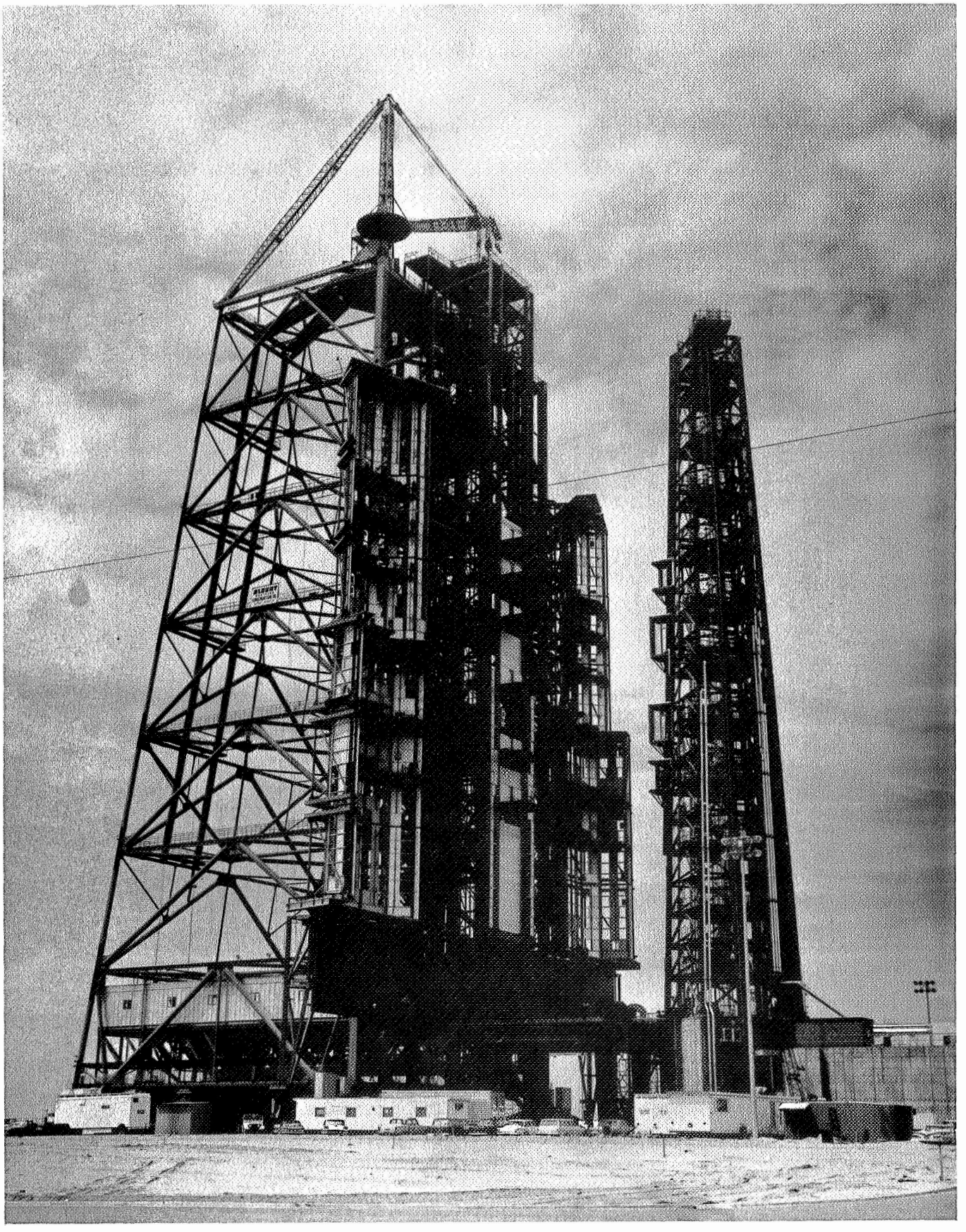


Fig. 23 SATURN SERVICE STRUCTURE II with UMBILICAL TOWER, SATURN Launch Complex 37